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SOVIET SOIL SCIENCE

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A TRANSLATION
OF POCHVOVEDENIYE

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SOVIET SOIL SCIENCE

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THE ORIGIN OF SPECIES OF CHARLES DARWIN (100th ANNIVERSARY OF THE DATE OF PUBLICATION)

M. S. GILYAROV

Most prominent among the products of scientific literature which may properly be called classic, among works in biology produced more than a century ago, is "The Origin of Species" by Charles Darwin.

Biologists throughout the world are observing the 100th anniversary of the publication date of this classic which has brought about a genuine revolution in biology. "The Origin of Species" has forced biologists and wide circles of society to look at the organic world in a new way, and to re-examine earlier concepts, which have been propagated for centuries by church doctrines and which have been accepted to a great extent by the science of the pre-Darwinian period.

Charles Darwin's book was the result of half a century of work by a learned man who wholeheartedly devoted all his efforts to the service of science; recently, (February 12th, 1959), the 150th anniversary of the birth of Charles Darwin was observed in our press.

In "The Origin of Species" Darwin, in simple and clear language within reach of laymen, showed that all the variety of the organic world is the result not of the will of the "Creator," as he creationists taught, but the result of a long historical process and that this variety is a natural result of a continuously active material actor – natural selection.

The idea of evolution and of organic evolution were repeatedly expressed in various forms even before Darwin. In reviewing the history of the development of views on the origin of species ound at the beginning of the book, Darwin himelf meticulously listed those of his predecessors who expressed ideas on the successiveness of pecies, and on organic evolution. But even ere, tracing the characteristics of the successve similarity in a series of organisms the ounders of morphology – Goethe, Oken, Owen, Cuvier and even Genebaur later viewed this imilarity purely idealistically as the development of a "plan of structure."

The brilliant evolutionist Jean Lamarck (150th anniversary of the appearance of his outstanding book "Philosophy of Zoology" is also being observed in this anniversary year of the theory of evolution) in order to explain organic evolution, had to resort to the vague ideas of the "inner striving toward perfection" of organisms and had to acknowledge virtually the principle of "primordial expediency, the inner purpose." Even the materialistic side of Lamarck's teaching – concept of the succession of acquired changes as the cause of the evolution of organisms, foresaw the primordial expediency of the reaction of organisms to external conditions.

The force of Darwin's theory lay in that he explained materialistically the appearance of expediency in the organic world, showed the relativity of adaptability of organisms to the conditions of their existence and the possibility of natural selection of forms fitted for life under given concrete conditions. Such a possibility exists, according to Darwin's doctrine, because the potential power of reproduction and the actual birth rate of all species considerably exceeds the number of individuals that survive under given conditions. On an average, those whose characteristics of organization most correspond to specific conditions of existence survive from the large number of varying individuals as a result of a high variability of organisms.

A gradual adaptation of the descendants of any given species to ever more different conditions, strengthened by natural selection, leads to an increasingly greater divergence of features, to the appearance of varieties differing from one another, and, in the end, with an intensification of the differences among the emerging varieties and a dying off of the initial and transitional forms – results in the isolation of new species adapted to different (as compared with initial) conditions of environment and enter into different relationships with the environment.

Thus, as formulated by our brilliant successor to Darwin and ardent supporter of his doctrine – Timiryazev (8) " . . . variety is the beginning of species; species is a well-defined variety."

Certain critics of Darwin have spoken out against this argument in his teaching, considering that by such an interpretation the boundary between the concepts "variety" and "species," the qualitative difference of these categories, disappears. Analyzing similar objections, we should, however, consider the fundamental tenths of dialectical materialism in the question of the limits (boundaries) of phenomena in nature. Lenin twice clearly formulated these tenets.

"The fundamental tenet of Marxist dialectics consists in that all facets in nature and society are relative (flexible) and mobile, that there is no one single phenomenon which could not under certain conditions become its opposite." So Lenin wrote in his article "Pamphlet of Junius" (V.I. Lenin, Works, 4th edition, Volume 22, page 295). We find Lenin's almost identical words elsewhere: "Of course, all distinctions (facets) both in nature and society, are mobile, to a certain extent relative (flexible) variable, and not dead" (Works, 4th edition, Volume 17, page 329).

Lenin's formulations on the boundaries or limits of natural phenomena were voiced in the statements of Friedrich Engels. Engels wrote that "hard and fast lines are incompatible with the theory of evolution. Even the border line between vertebrates and invertebrates is now no longer rigid." "Dialectics which likewise knows no hard and fast lines, no unconditional, universally valid 'either – or' which bridges the fixed metaphysical differences and besides 'either – or' recognizes also in the right place 'both this and that' and reconciles the opposites, is the sole method of though appropriate in the highest degree corresponding to the present stage of evolution of natural science" (Friedrich Engels, Dialectics of Nature. Gospolitizdat. 1955, page 167).

These statements maintain that we cannot draw sharp distinctions between variety and species to which Darwin too, turned his attention. And, at the same time, we must remember that "life and growth in nature also include slow evolution and rapid leaps, interruptions in gradual development" (V.I. Lenin, Works, 4th edition, Volume 16, page 319).

The formation of a new species – this is also an interruption in gradual development. Species is the developed unity; in the case of sexually reproduced organisms this unity is seen, first of all, in the capacity (although potential) toward normal interbreeding of the representatives of the different populations. Isolation of a new species is always an interruption in such unity.

Darwin paid much attention to defining the concept "species"; Darwin saw the complexity and contradictoriness of this systematic category and pointed out that we cannot find any single criterion which would suffice for determining species.

A more profound analysis of the criteria of species made later with respect to zoological subjects by Semenov-Tyan-Shanskiy (7) and with respect to botanical subjects by Komarov (3), species characteristics observed by Lysenko (4), and other determinations, confirm the correctness of Darwin's views on the complexity of the actual taxonomic concept of "species."

Typical of Darwin's train of thought was the spontaneous understanding of the fundamental tenet of dialectical materialism on the transition from accumulated small quantitative changes to a profound qualitative change. In essence, the basic idea of Darwin on the gradually accumulated "variations" which lead (by divergence in different directions of the characteristics of the initial form under the influence of external conditions) to the formation of new species results in this.

The formation of new species and their isolation is, of course, a qualitative jump. However, this is a jump to be understood in the philosophical sense. The Darwinian concept that "nature does not jump" is proof only of the fact that Darwin did not consider as possible the spontaneous emergence of a new species which had not been made ready by the course of historical evolution. We should conceive of Darwin's statement only as opposition to the beliefs in the possibility of "acts of creation" after "catastrophes" preached by Cuvier and which prevailed until victory of the ideas of transformism. In 1830, a whole year before Darwin's voyage aboard the HMS "Beagle," during which time he collected voluminous data, and thought over the fundamental tenets of his theory, the views of Cuvier formally triumphed over the still naive transformistic ideas of Is. Geoffroy St. Hilaire.

If Darwin did not subjectively acknowledge jumps, he proved objectively, by giving a materialistic explanation to how new species are formed, the existence of these jumps (formation of new species), of course, failing to realize the dialectic nature of his ideas. Not without reason did Karl Marx write to Friedrich Engels in 1860 on "The Origin of Species" that "this book provides the natural historical basis for our views" (Marx and Engels. Works. Volume 22, 1929, page 551) and Engels in a speech at Marx's grave compared the principle of organic evolution exposed by Darwin with the principle of evolution of human society, as established by Marx; well-known also is the same high appraisal of Darwin made by Lenin, despite the fact that Marx and Engels had already observed several weak arguments in Darwin's ideas.

Darwin, himself, in his "Autobiography"
oints out that when he was sailing aboard the
MS Beagle, he developed ideas on the histori-
al evolution of species. He writes: "Finding
pampas formations mammoth fossile animals
overed with armor quite similar to present-day
rmadillos has made a strong impression on me.
hen I was attracted by the gradual shift of
milar animal forms, as they migrated south of
e continent and, finally, too, I was attracted
the South American character of the natural
roducts of the Galapagos archipelago, and,
articularly by the slight differences represented
the inhabitants of each separate island" (1).

To substantiate his chief idea, Darwin turns
agricultural practice, where artificial selec-
on is being widely used in the field of plant
ltivation and animal husbandry. These data
ave a graphic picture of the vast creative role
selection.

As to the importance of this it is of interest
present the view of the President of the 15th
ternational Zoological Congress, G. de Beer,
ho noted in the preface to the anniversary
lition of the first draft of Darwin's theory
at "selection and not mutation directs the
ourse of evolution. As the frequency of muta-
ons increases, the agents responsible for the
utations, including atomic energy, may, as a
esult, increase the number of imperfect and
onvital individuals and thus increase the num-
er of victims of selection, but this does not
ave an effect on the course of evolution" (9).

Drawing upon data on agricultural practice
solving the cardinal theoretical problem of
ology is the strength of Darwin's doctrine;
e strength, too, of present-day Darwinism
es in the close association of theory and prac-
ce.

A striking characteristic of the creater of
he Origin of Species" was his profound eru-
tion and ability to tie together data of various
anches of science: zoology, botany, geo-
aphy, geology. Darwin himself notes that
delible influence which the concepts developed
"The Principles of Geology" by Charles Lyell
d on the formulation of his views.

Repeated emphasis is being made in our
ess today, particularly by the President of
Academy of Sciences, A.N. Nesmeyanov,
at the development of science is especially
ormy at the juncture of various adjacent
anches of science, that mastering the data
d methods of the various branches of science
ll originate new periods in the growth of
ience. Darwinism became such a period of
werful growth of many branches of biology
d is now, a hundred years later, the basis
the scientific views of most biologists in
world. In Darwin's book, his keeness of
servation, richness of data, modesty, self-criticism, and exceptional severity of logical thought, and profoundness of formulations and deductions strike the reader even today.

Over the course of 100 years Darwinism has withstood numerous attacks: Darwin's doctrine, strengthened and developed by scientific works in various countries, has not lost importance in biology and is being used by materialistic philosophy in its struggle with idealistic conceptions.

The appearance of Darwin's book 100 years ago was in his time the greatest triumph of materialism in that field of natural science where the positions of clericalism and idealism were especially powerful. "The Origin of Species" dealt idealism a double blow in the field of biology: in the first place, the book outlined historic organic evolution and its natural laws and, in the second place, the book showed that the principle of teleology does not govern the organic world but rather the principle of causal relationships, which has already earlier won the recognition of other branches of natural science. The theory of natural selection enabled us to explain the origin of those adaptations which could not be rationally explained by the hypothesis of the evolutionists of the pre-Darwinian period (protective coloring, passive organs of defense). This also explains the enormous influence which Darwin's doctrine had among naturalists and within wide circles of readers, and those attacks to which his doctrine was subjected from the very first days by both church votaries and reactionary scholars.

The struggle for Darwinism was a struggle for materialism, and so it is no wonder that there arose in its defense not only such leading scholars as T. Huxley in England, E. Gekkel' in Germany, K.A. Timiryazev, M.A. Menzbir, A.N. Severtsov, and V.M. Shimkevich in Russia, but even eminent enlightened publicists such as, for example, D.I. Pisarev in our country.

A profoundly materialistic basis of Darwin's teaching, the role of Darwinism in its struggle with religious fallacies, explains why Darwinism found a second home in the USSR, while in many states of the United States it was forbidden to preach Darwinism and "monkey trials" were possible.

Characteristic of Darwinism in our country is the creative trend which has adopted the words of I.V. Michurin as its slogan: "we cannot await favors from nature. Our task is to take them from her." Altering nature is impossible without knowing her laws, and we do not forget that the most important laws in organic evolution were revealed by Charles Darwin.

Setting aside numerous important objections and corrections which have been made with respect to the different sides of Darwin's doctrine over its 100 year history, we must, nevertheless, note that "when Darwin speaks of natural selection, he wanders from those causes which are responsible for changes in separate individuals and discusses, first of all, how similar individual variations gradually become characteristics of a certain race, variety, or species" (Friedrich Engels, "Anti-Duhring" Gos. Izd. Polit. Liter. 1953, pages 66-67).

The problem of the origin, causes and nature of variability of organisms, which Darwin did not raise in examining the existing variability of organisms as a condition of effect of selection, has not found at present a generally accepted convincing solution. Solving this problem is one of the basic tasks of the present-day stage of development of biology.

The spontaneously dialectical materialistic ideas of historical evolution by accumulation of small unnoticeable quantitative changes, occasionally hidden during isochronous or short-term (short-range) observations leading to large qualitative changes, is the principle with which Darwin approached not only the solution of the problem of organic evolution but also the solution of other problems in the evolution of nature. In particular, this was reflected in the Darwinian explanation of the origin of coral reefs. "I continuously made observations on the shores of South America of the effect of the rise of the mainland with respect to erosion and formation of sedimentary rocks. This naturally forced me to reflect a great deal on the consequences of a lowering and it would take little imagination to notice the continuous deposit of sediments in development of coral." So Darwin (1) wrote of how he arrived at the idea of the origin of coral reefs. Small annual accumulations of polypi are the cause of the formation of coral reefs and atolls, according to Darwin.

This principle of calculating the accumulation of small changes leading to qualitative displacements was assumed by Darwin as the basis for his study of the soil-forming activity of earthworms. Darwin presented the first outline of results of his early observations on the soil-forming activity of earthworms at the Royal Geological Society and published it in 1839, soon after his return from a voyage on the HMS Beagle. Afterwards, he continued observations on earthworms throughout his entire life.

More than 13 years of observations did not shake but merely confirmed Darwin's conviction in the accuracy of his observations on the soil-forming activity of earthworms and, in 1881, he published his "swan song" – the book "Formation of a Vegetation Layer of Soil through Earthworm Activity" (2). In this book, which the famous English soil scientist E.J. Russell (6) referred to as "the most interesting book ever written on soil," Darwin shows how discarding worm excrement gradually leads to the formation of a humus layer of soil. In this book Darwin bitterly writes: "In 1859 Fisher rejected my conclusions on the participation assumed by earthworms in the formation of a vegetation layer, only because of a preconceived idea of their inability to do such work." The next remark by Darwin is of more general importance and illustrates his approach to solving the problems of evolution. "Here we again encounter – writes Darwin – that inability to summarize the results of constantly occurring phenomena which has already often impeded the progress of science." These last words are an allusion to those reactions which his principle of natural selection met with from metaphysically-minded opponents.

Darwin's conclusions on the activity of earthworms as a powerful factor in soil formation have been subsequently corroborated and developed by soil scientists of many nations, including, in Russia, G.N. Vysotskiy, N.A. Dimo and recently by many other Soviet scholars.

The ideas on organic evolution expounded in "The Origin of Species" which has largely determined the general trend of natural scientific thought at the end of the 19th century, have also had an effect on the development of soil science. There is no doubt that the approach to the solution of problems and Darwin's method have been expressed to some degree also in the creative genius of V.V. Dokuchayev. The idea of evolution as applied to all nature, established in the minds of the progressive scholars of the past century, found a new expression and confirmation in Dokuchayevian genetic soil science developed in Russia. The doctrine on the development of soils found its clearest expression in the ideas of V.R. Vil'yams.

Another science founded in Russia, very important for soil science – the study of the forest – was developed under the direct influence of Darwin's ideas. Morozov (5) begins "Science of the Forest" with a brilliant analysis of the intraspecies relationships in the forest, by enriching the ideas of the interconditioning effect of organisms on one another and on the environment.

Darwin's doctrine played an important role in the development of the hypothesis on the origin and evolution of life on earth. Darwin himself avoided resolving this problem, by resorting to the hypothesis of pansophism. But, relying on the theory of natural selection, A.I. Oparin developed his own hypothesis on the origin of life and his viewpoint is presently being widely accepted by biologists and materialists throughout the world.

It is difficult to list all those branches of

tural science which were stormily developed
der the influence of Darwin's ideas. Let us
oint out that soil science data are of great in-
rest for subsequent development of several
ends in the theory of organic evolution. Thus,
resently, the view on soil as on environment
rough which occurs a transition of many groups
invertebrates from the water form of life
ring their phylogenesis to the land form has
on wide recognition. The specific character-
stics of the physicochemical regime of soils
able us to understand the sequence of adapta-
on of the water groups of organisms, at first
life in the soil, and only then on the soil sur-
ce, and to establish the origin of many groups
land organisms.

The problems of historical organic evolution,
e factors, methods and patterns of this evolu-
on have not been exhausted by Darwin's doc-
ine but rather raised by it, and are now being
idely discussed and studied. Friedrich Engels
ighly appraised Darwin "who dealt the severest
low to metaphysical views on nature, by prov-
g that the whole present-day organic world,
lants and animals, and, as a result, even the
uman being are a product of the process of
volution, which has lasted millions of years"
. Engels. Development of Socialism from
topia to Science. Gospolitizdat, 1952, page
1).

Herein lies the greatest service of Charles
arwin to the science of the world.

BIBLIOGRAPHY

1. DARWIN, CHARLES. 1935. Origin of Species. Sel'khozgiz.
2. DARWIN, CHARLES. 1899. Formation of a vegetation layer of soil through earthworm activity. St. Petersburg.
3. KOMAROV, V. L. 1940. Study of plant species. Izd. Akad. Nauk. SSSR. Moscow and Leningrad.
4. LYSENKO, T. D. 1951. What's new in the study of biological species. Sel'khozgiz.
5. MOROZOV, G. F. 1950. Science of the forest. Goslesbumizdat.
6. RUSSELL, E. J. 1931. Soil conditions and growth of plants. Sel'khozgiz.
7. SEMENOV-TYAN-SHANSKIY, A. P. 1910. Taxonomic limits of species and its subdivisions. Izd. Akad. Nauk. St. Petersburg.
8. TIMIRYAZEV, K. A. 1919. Charles Darwin and his teaching. 7th edition.
9. DE FOREWORD, G. BEER, CHARLES DARWIN, and A. R. WALLACE. 1958. Evolution by natural selection. Cambridge University Press.

CONDITIONS FOR FORMATION OF HUMIN-LIKE COMPOUNDS BY MOLD FUNGI

A. G. ROMANKOVA and YE. A. NAGALYUK

A number of investigators have pointed out that mold and basidiomycetous fungi participate in the synthesis of high-molecular humic compounds. The majority of these people emphasize the importance of fungi in this process of oxidizing enzymes when they express their belief in the direct participation of fungi in the formation of humic compounds (10, 5, 9, 2, 11, 13 and others).

Some investigators believe that the biosynthesis of humic compounds is achieved by bacteria. However, the positive role of fungi consists in the fact that their mycelia constitute a source of nitrogenous food for bacteria after autolysis and this facilitates the rapid increase of the latter (2). However, experimental work that would confirm the participation of different groups of microorganisms in the biosynthesis of humic compounds is still insufficient and only further research will provide a complete answer to this question.

It is necessary to find those nutritional conditions which make possible the formation of humin-like compounds by a large group of soil microorganisms, including fungi, bacteria, and actinomycetes. We know that each of these groups of microorganisms includes representatives with different physiological and biochemical peculiarities which determine their relationship to the source of food and the chemical composition of the end products of biosynthesis produced by the microorganisms. The study of this question with such objects as mold fungi is interesting because this group of microorganisms is widely distributed throughout different soil groups and possesses great possibilities in the use of substrata which are not too available to bacteria. Tannins which constitute one of the sources for the formation of humic compounds can serve as an example.

Our experiments showed that under certain nutritional conditions mold fungi may flourish but will not form humic compounds. When certain components were present in the nutrient solution, humic compounds were formed in cultures of these fungi.

According to data obtained by Romankova and Nagalyuk (7), the formation of humin-like compounds in cultures of Penicillium viridicatum was favorably affected by the following amino acids: α-amino caproic acid, phenylalanine, and tyrosine; in addition, the favorable role of cystine was noted. However, the best results were obtained when we included mineral and organic nitrogen simultaneously in the medium. As we have already shown, phosphorus plays an important role in the formation of humin-like compounds by mold fungi. When the amount of phosphorus in the nutrient medium was increased, an increase was noted in the carbon content of the humin-like compounds secreted from the mycelia. In accordance with these data, we doubled the phosphorus dosage over the amount prescribed for Chapek's medium.

We have investigated the question of the importance of the sources of carbon in the formation of humin-like compounds by fungi. When studying the effect of glucose, sorbitol, and glucuronic acid on the formation of humin-like compounds precipitated from the culture, Plotho (14) found that the precipitate was not formed in a medium with glucose; the best results in the experiments with fungi were obtained in a medium with glucuronic acid.

Cultures of the fungus. Penicillium viridicatum served as the object of our investigations. We tested the following sources of carbon: glucose, sugar, glycerin, tannin, and pectin. As is well known, the pectinic substances included galacturonic acid, which reaches 72% of such substances.

Experimental Section

We used the following method. The nutrient medium which contained sucrose and the mineral salts of $NaNO_3$ — 3 grams; KH_2PO_4 — 1 gram;

$MgSO_4$ — 0.5 grams; KCl — 0.5 grams, $ZnSO_4$ — 0.1 grams; $CuSO_4$ — 0.01 grams; $MnSO_4$ — 0.02 grams; water — 1000 ml was poured into 1000-ml Erlenmeyer flasks (150 ml into each flask) and after sterilization in an autoclave, inoculated with fungi conidia. A dense film of mycelia was usually formed within six days after inoculation. The experiments were conducted at a temperature of 28-30°C. At the end of this period the cultural medium was decanted, the mycelia were washed with sterile d distilled water, and a sterile medium of different composition was introduced under the mycelium film. A carbon source was added to this new medium in quantities calculated to start with the amount of carbon contained in 30 g of glucose for each 1000 ml of the medium. We used inorganic nitrates in the form of $NaNO_3$ or in a mixture with the organic form ($NaNO_3$ + α-amino caproic acid).

The total nitrogen content was the same in both treatments (65.8 mg/100 ml of medium). In the treatments in which a mixture of the inorganic and organic forms were used, both components were equalized in nitrogen content. We introduced phosphorus in the form of 0.8 ml of concentrated phosphoric acid solution containing the following mineral salts: K_2SO_4 — 0.58 g; $CuSO_4$ — 0.1 g; $MnSO_4$ — 0.2 g; $Co(NO_3)_2$ — 0.05 g; water — 1000 ml.

Thus, the medium for growth of the mycelia differed in composition from the medium for the formation of humin-like compounds in the interchangeable cultures. It should be noted that when the fungi were cultured without any change from the first medium, either no formation of humin-like substances was observed at all or only after three or four months had elapsed from the beginning of the experiment.

The total duration of the experiments with interchangeable cultures amounted to 21-30 days, after which the carbon content in the separated humin-like compounds was determined. Here we utilized the method developed in the Department of Soil Science of the Leningrad University (7).

In addition to determining the carbon content, we determined the amount of nitrogen by the Kjeldahl method, the peroxidases (by the Walstetter method), and proteinases by the viscosimeter method. The presence of polyphenols in the culture medium was noted by a qualitative reaction with ferric chloride.

The data of Table 1 indicate that the formation of humin-like compounds is affected by the source of the carbon and the combinations in which it occurs with other components of the medium, particularly with nitrogen.

Thus, humin-like compounds were not formed in a medium with $NaNO_3$ as the sole source of nitrogen (medium a) if the source of carbon was glucose or glycerin, or also pectin. Humin-like compounds were obtained in this medium only in the treatments with tannin.

It is essential to call attention to the very low activity of the proteinase in the treatments with glucose and glycerin. It is possible that this is the reason why humin-like compounds were not precipitated, in spite of the appearance of polyphenols in the medium, since the formation of humin-like compounds requires organic nitrogen in the form of polypeptides or amino acids in additionto polyphenols.

If pectin served as the source of carbon in experiments with medium (a), the activity of the proteinase and the peroxidase was noticeably increased. However, pectin turned out to be not too favorable as a source of carbon for the biosynthesis of polyphenols; in this case humin-like compounds were not found in the culture medium since one of the components essential for their formation was lacking.

Finally, in the treatments with tannin as the source of carbon and with nitrogen in the form of $NaNO_3$ biosynthesis was completed successfully with the formation of humin-like compounds. In this case the activity of proteinase in the medium was highest, which undoubtedly ensured the admittance of organic nitrogen into the medium. The polyphenol reaction was positive this time, i. e., there were components essential for the biosynthesis of humin-like compounds. In the medium with a mixture of mineral and organic nitrogen (b), humin-like compounds were formed in the treatments with glucose, pectin, tannin, and also when pectin was mixed with tannin.

In experiments with medium (c), the source of carbon was pectin while the nitrogen was added in the form of dead bacteria, which led to a strong increase in the activity of the proteinase. In this case polyphenols were not formed. The very small ratio of carbon to nitrogen in the precipitates obtained in the last treatment (4:1) indicates that these precipitates are more likely associated with proteins and not with humin-like compounds.

In a medium with glucose or pectin and a mixture of mineral nitrogen with organic, the ratio of carbon to nitrogen reached 6.5-11.5 while the C: N ratio in the humic acids taken from the soil is usually close to 13 (4).

The C:N ratio in humin-like compounds varies over a wide range, depending on the nutrient sources. Thus, for example, Table 2 shows the changes in the C:N ratio in humin-like compounds which are being formed due to the addition of calcium to the nutrient medium.

Table 1

Effect of sources of carbon and nitrogen on the formation of humin-like compounds in cultures of Penicillium viridicatum

Carbon source	Humin-like compounds, mg/100 ml of culture medium			Enzymes converted to 0.1 g of absolutely dry mycelia		Reaction with $FeCl_3$
				Proteinase	Peroxidase	
				Time of gelatin, flow seconds	Purpurogallin, mg	
	C	N	C:N			
A. Medium with inorganic nitrogen $NaNO_3$						
Glucose	0	0	—	15.4	9.2	+
Glycerin	0	0	—	0.5	34.3	+
Pectin	0	0	—	128.0	66.0	—
Tannin	3.2	0.3	10.6	144.0	27.0	+
b. Medium with mixture of inorganic and organic nitrogen $NaNO_3$ + α-amino caproic acid						
Glucose	33.4	2.9	11.5	67.0	43.0	+
Pectin	13.0	2.0	6.5	118.8	88.0	+
Tannin	7.0	1.0	7.0	112.2	13.3	+
Pectin + tannin	11.6	1.46	8.0	115.0	13.0	+
c. Medium with nitrogen from bacteria cells B. coli						
Pectin	41.0	10.0	4.1	308.2	74.0	—

Table 2

Effect of calcium on the formation of humin-like compounds by the fungus Penicillium viridicatum

Carbon source	Humin-like compounds, in mg/g absolutely dry mycelium			Enzymes converted to 0.1 g of absolutely dry mycelia	
				Proteinase	Catalase
	C	N	C:N	Time of gelatin flow, seconds	Ml of 0.1 $KMnO_4$
Sucrose + tannin without $CaCO_3$	13.5	0.45	30	25.1	120
Same, with $CaCO_3$	8.4	0.48	17	10.8	166
Pectin + tannin, with $CaCO_3$	8.1	0.78	11.6	37.6	381

In the experiments conducted (Table 2), the basic sources of carbon were sucrose or pectin, tannin was added in small amounts (0.1%-0.5%) however. Mineral salts were introduced into these media in the quantities previously mentioned in the description of the composition of the medium for the interchangeable solution which was introduced under the prepared mycelia of the fungi. The largest C:N ratio, which was 30, was observed in the treatment with sucrose and tannin without calcium. When these sources of carbon were present in a medium with $CaCO_3$, however, the C:N ratio in the humin-like compounds reached 17, which approximated the ratio in fulvic acids extracted from the soil.

Thus, the formation of humin-like compounds by mold fungi depends both on the sources of carbon and nitrogen and on certain other components of the nutrient medium, particularly on the presence of calcium. The best results in the formation of humin-like compounds were obtained in the treatments with $CaCO_3$ when both pectin and tannin were present as the source of carbon (pectin — 2%, tannin — 0.5%).

By selecting the conditions of the nutrient, it was possible to stimulate the formation of humin-like compounds in cultures of mold fungi; at the same time, the compounds obtained in different media differed in their C:N ratios. At times they were closer to the fulvic acids, at others to the humin acids. The latter were observed in those cases in which the nutrient medium contained tannin and calcium.

Our experiments also showed that the formation of humin-like compounds by fungi was also affected by substances which act as catalyzers in oxidation reactions. It is well known, for example, that the enzyme ascorbic acid oxidase, which is a protein complex that contains copper, has high catalytic activity (6). This enzyme catalyzes the oxidation of ascorbic acid. When we added 0.05% of the latter to the nutrient solution, the amount of humin-like compounds in it increased. The source of carbon in these experiments was tannin or pectin while the source of nitrogen was $NaNO_3$. The experiments lasted 28-30 days at a temperature of 25-30°C.

The favorable effect of ascorbic acid on the biosynthesis of humin-like compounds in cultures of the species of fungi tested was shown most clearly in the treatments in which pectin was the source of carbon; in the treatments with tannin the effect was less notable since the tannin itself stimulated the formation of humin-like compounds. The production of humin-like compounds increased 18 times in the first case when ascorbic acid was added and only 1.2 times in the experiments with tannin.

The data we obtained agree with the ideas of Trusov (8), Kononova (4), Dragunov (3), and Kuester (11) on the formation of humic acids as condensation products of polyphenols and their derivatives with polypeptides or amino acids. In our experiments, as we noted previously, the fungi tested did not form humin-like compounds when one of these components was absent or present in insufficient amounts. Thus, for example, in the treatments with glucose and a mineral source of nitrogen polyphenols were formed but the autolysis of the mycelia was retarded. In order to increase the activity of the proteinase which would stimulate the decomposition products of the mycelia in the medium in the form of polypeptides and amino acids, it was necessary to include organic nitrogen in the medium; in this case the activity of the proteinase increased considerably (Table 1, Media a and b) and the formation of humin-like compounds was observed. Along with this, the addition of polyphenols like tannin turned out to be very effective.

Under natural conditions mold fungi make use of carbon in cellular tissues, not in pure form, but frequently mixed with pectins and tannin. As our experiments showed, a mixture of pectins and tannins had a favorable effect on the biosynthesis of humin like compounds in cultures of fungi; while sugar which was utilized rapidly by the fungi could scarcely serve as a source for forming polyphenols under natural conditions, i. e., in the soil. This component which is important in the biosynthesis of humin-like compounds enters the soil together with humifying plant residues that are rich in tannins; an example is the litter from stands of oaks and from tanner's sumac and many other plants.

The ash and organic composition of decomposing plant residues apparently determine whether mold fungi will develop on them to form humin-like compounds.

In connection with this question it is interesting to note that some species of plants contain pectins in considerable amounts, for example, moss and lichens. Other species of plants, (legumes for example), enrich the soil with organic nitrogen. The ash content of the soil is also changed to a considerable extent by vegetation. For example, soils under oaks are richer in calcium (1). Experiments with pure cultures of fungi have convinced us that calcium facilitates the formation of humin-like compounds.

In developing the question of the suitability of different vegetative substrata for forming humin-like compounds by mold fungi, we carried out experiments with oak leaf litter and a mixture of grasses (clover and timothy). The pulverized plant material, which was first mixed with sand and sterilized in flasks, was inoculated with a pure culture of Penicillium viridicatum and moistened with a sterile solution containing 1% glucose, 0.01% $CuSO_4$, 0.02% $MnSO_4$, and 0.1% $CaCO_3$ (moistening was carried up to a calculated 60% of the total moisture capacity). Later, as the plant material dried out, it was moistened with sterile water according to its weight. An analysis was made after six months of the soil-forming humic and fulvic acids to determine the carbon content

Table 3

Carbon content in products of the humification of vegetative material (in g/100 g of absolutely dry mixture: vegetative material:sand gl:10)[a]

Vegetative material	Carbon			With humic acids
	Total content in water extract	Humic acids	Fulvic acids	With fulvic acids
Oak leaves	0.67	0.12	0.55	0.21
Clover and timothy	3.34	0.30	3.04	0.10

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[a] Analyst M. V. Kharitonova.

(by the Tyurin method). The data we obtained are presented in Table 3.

The experimental results showed that pure cultures of the fungi decomposed sterile vegetative substrata with the formation of humin-like compounds and, which is very important, did this in the absence of bacteria, which would be seen by the negative results from inoculating meat-peptone agar with the decomposing material. According to calculations made with the absolutely dry, ashless substance, the carbon content of the humic acids formed by the decomposition of oak leaves was 48.8% while the nitrogen content was 3.71%, i. e., the C:N ratio was 13.

The humification products of clover and timothy showed a dominance of fulvic acids over humic acids. The total carbon content in this case was several times the carbon content in the humified products of oak leaves.

Conclusions

1. The participation of mold fungi in the biosynthesis of humin-like substances was confirmed experimentally, as shown by experiments with pure cultures of fungi on nutrient media of known chemical composition and also the results of experiments on the decomposition of different plant material substrata by these same fungi.

2. Present investigation permits one to conclude that the formation of humin-like compounds by mold fungi depends to a considerable extent on the sources of nitrogen and carbon, as well as on the presence of calcium in the nutrient medium.

3. The selection of favorable conditions of nutrition made it possible to stimulate the biosynthesis of humin-like compounds in pure cultures of fungi, and the best results were obtained in experiments with nutrient media which contained inorganic nitrogen mixed with organic nitrogen. Of the sources of carbon, the tannins and pectins had a favorable effect on the formation of humin-like compounds.

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BIBLIOGRAPHY

1. BOBRITSKAYA, M. A. 1953. Ash content of oak leaves. Pochvovedeniye No. 7.
2. GEL'TSER, F. YU. 1940. The Importance of microorganisms in the formation of humus and stable soil structure. Sel'khozgiz.
3. DRAGUNOV, S. S. 1948. A comparative study of humic acids in soils and peats. Pochvovedeniye, No. 7.
4. KONONOVA M. M. 1951. The problem of soil humus and the present problems in its study. Izdatel'stvo AN SSSR.
5. MISHUSTIN, YE.N., S. S. DRAGUNOV and O. I. Pushkinskaya. 1956. The role of microorganisms in the synthesis of humic compounds. Izv. AN SSSR, Seriya biol. No. 6.
6. MIKHLIN, D. M. 1956. Biological Oxidation. Izdatel'stvo AN SSSR.

7. ROMANKOVA, A. G. and YE. A. NAGALYUK. 1959. The effect of the culturing conditions on the mold fungi on their formation of humin-like compounds. Tr. Biol. in-ta Leningr. un-ta, No. 1, Izd. LGU.

8. TRUSOV, G. M. 1917. Material on the Study of Soil Humus. Processes in the Formation of Humic Acid, Parts I, II.

9. DION, O. 1952. Production and properties of polyphenol oxydase from the fungus Polyporus versicolor. Canad. J. Bot., Vol. 30, I.

10. KONONOVA, M. M. and I. V. ALEXANDROVA. 1956. Biochemie des processus de formation des matierés humiaues. 6-e Congr. intern. Sci. Sol. C. R. III, Paris.

11. KUESTER, E. 1953. Microbielle Polyphenoloxidasen und Humusbildung. Zbl. Bakteriol. Parasitenkunde, Infectionskrankh. und Hig. Bd. 160.

12. LAATSH, W., and L. HOOPS. 1952. Ueber Huminsauren des pilzes Spicaris elegans. Z. Pflanzenernaehr. Dueng. Bodenkunde. Bd. 58, H 103.

13. MAGEMOT, F. 1957. Acidité ionique et population fongiaues des bois. II. Influence les conditions de culture sur la croissance et la synthese des acides humiques. Rev. Gén. Bot., v. 766.

14. PLOTHO, O. 1951. Humusbildung der microorganismen. Z. Pflanzernaehr. Duengs. Bodenkunde. Bd. 100, H. 2.

ORGANIC NATURE OF THE BASIC SOIL GROUPS OF TADZHIKISTAN

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The subject of our studies was the organic nature of the basic soil groups of Tadzhikistan, which were developed under different natural conditions determined by vertical zonality against a background of general changes in climate in various sections of this Oblast', which is complex in its orography.

The names given below and a brief description of the soils studied have been accepted based on the work of soil scientists Kerzum (3), Grabovskaya (2 and 3) and Kuteminskiy (8).

The soil groups subjected to study are:

Soil	Site of profile number Absolute elevation	Vegetation	Parent material	Remarks
Sierozem Soil Group				
Light sierozem	Southwest Tadzhikistan. High terrace of Vakhshskaya Valley, 460 m	Ephemeral reaches maximum growth in April, completely dried out during first half of June	Loess	Soils of valleys and foothills of Tadzhikistan
Ordinary sierozem	Southwest Tadzhikistan. Obi-Kiiskaya Valley, 650 m	Coarse grass with predominance of *Cousinia polycephala*, *Phlonis bucharica*, *Carex pachystilis* encountered	Loess	
Dark sierozem	Southwest Tadzhikistan. Terekli-Tau mountain range, 1,700 m	Grassy with predominance of *Carex pachystilis*	Loess	
Cinnamon-Brown Soil Group				
Cinnamon-brown carbonate soil	Southwest Tadzhikistan. Gardaniuchiti mountain range, 2,200 m	Varied grass — grain rosarium.	Loess	
Cinnamon-brown typical soil	Southern slope of Gissarskiy mountain ridge, 1,900 m	Meadow with variety of grasses amidst maple forest. *Dactylis glomerata*, *Hordeum bulbosum* predominate	Granite diluvium	
Cinnamon-brown light soil	Northern slope of Turkestanskiy mountain ridge, 2,500 m	Grassy with predominance of *Festuca sulcata*, occasionally isolated Juniper trees	Schist (slate) diluvium	

Continued from preceding page

Soil	Site of profile number Absolute elevation	Vegetation	Parent material	Remarks
Cinnamon-brown dark soil	Northern slope of Petr-Pervyy mountain ridge, 2,500 m	Grassy (Rumex, Dactilis glomerata, Rosalutea, Prangos pabularia, Poa bulbosa)	Diluvium of sandstone and clay	
High Mountain Soils				
High mountain forest soil under Juniper	Northern slope of Turkestanskiy mountain ridge, 2,500 m	Juniper, moss, grass	Limestone diluvium	
Mountain-meadow typical soil	Northern slope of Petr-Pervyy, mountain ridge, 3,000 m	Grassy	Diluvium of red-colored sandstone	From 30 cm down grows a quantity of sandstone fragments or detritus
Mountain-meadow sod peat soil	North-northwest slope of Petr-Pervyy mountain ridge, 3,200 m	Artemisia sp., Cousinia sp., Festuca sulcata	Limestone diluvium	From 30 cm begins a stony loose rock horizon
High mountain sod-meadow soil	Gissarskiy mountain ridge. Anzobskiy mountain pass, 3,380 m	Fine alpine grass, Carex pseudofoetida, Allium monadelfum, predominate	Diluvium of schist (slate)	

Samples of all these soils were taken during the period of maximum vegetative growth. Then the above-surface and subsurface (root) mass of living plants were calculated.

To calculate the above-surface part of plants we selected a plot 1 m² in area with a vegetation most typical of the given area in composition and density. The plants were carefully cut and hung in an air-dried state.

To calculate the root mass, the soil samples were extracted with a steel cylinder 10 cm high and in an exact capacity of one cubic decimeter. The three upper layers (0-10, 10-20, and 20-30 cm) were replicated five times and below three times. After air drying the soil (for determining its bulk density) the roots were washed through two sieves with a pore diameter of 1 and 0.25 mm. Thus, the entire root mass was divided into two fractions — large and fine, and at the same time, a practically complete recovery of all roots was achieved, even of the smallest ones. The washed roots were air-dried.

Samples for determining humus (according to the I. V. Tyurin method) were taken where root samples had been taken, with the same replication. Humus contents were computed in tons per ha based on bulk density data. Table 1 gives the results of these determinations. They show that the humus content depends upon the amount of vegetative mass in a given soil and also upon the character of vegetation and its root system.

Principal quantities of both roots (to 90%) and humus (to 65%) are concentrated in the upper 20 cm layer of soil. Absolute humus contents in the 0-20 cm layer are highest in the cinnamon-brown light soils (136 metric tons per ha) and in the cinnamon-brown typical soils (105 metric tons per ha), the vegetation of which is richer, while humus contents are the lowest in the light sierozem (26 metric tons per ha) with the poorest vegetation.

Table 1

Humus and root contents, metric tons per ha

Soil	Character of vegetation	Amount of air-dried mass of vegetation, g/1 m² of area	Depth, cm	Humus	Total roots	Including		Ratio	Amount in 0-20 cm layer in % of 0-50 cm layer	
						large roots	small roots	$\frac{\text{humus}}{\text{roots}}$	humus	roots
Light sierozem	Ephemeral grasses	26.8	0—20 0—100	25.8 41.0	11.0 11.4	— —	— —	2.35 3.60	63.0	96.5
Dark sierozem	Grass with predominance of reed grass	145.7	0—20 0—50	47.2 93.0	28.6 32.4	— —	— —	1.65 2.86	50.8	88.2
Cinnamon-brown carbonate	Variety of grasses with rosarium bushes	294.6	0—20 0—50	77.9 137.1	51.3 60.3	— —	— —	1.52 2.58	56.6	85.0
Cinnamon-brown typical	Meadow with variety of grasses amidst a maple forest	399.0	0—20 0—50	105.3 162.9	52.8 66.5	— —	— —	2.00 2.48	64.9	79.5
Cinnamon-brown light	Grass with predominance of steppe-grass	300.0	0—20 0—50	136.5 226.0	57.7 76.9	39.6 54.2	18.1 22.7	2.33 2.95	60.0	75.1
High mountain sod meadow	Alpine variety of grasses	111.4	0—20 0—50	78.5 128.4	31.4 35.0	25.9 28.7	5.5 6.3	2.48 3.67	61.1	89.8
High mountain forest	Juniper, moss, grass	220.6	0—20 0—50	89.1 179.4	50.4 61.2	37.1 44.8	13.3 16.4	1.77 2.91	49.8	82.2

But the ratio of humus content to root mass in various soils is not the same, as Kerzum (6) has already noted. The ratio is highest in soils with the smallest amount of plant mass-in the light sierozems (2.35) and in the high-mountain sod-meadow soils (2.48). This indicates indirectly the relatively more intensive accumulation of humus in these soils.

We must find the explanation of this, apparently, from the character of vegetation. Fine small roots of ephemera in light sierozem decompose more rapidly and easily than wood roots of scrubs and trees in cinnamon-brown soils. Besides, another factor appears here. An analysis[1] of the surface part of vegetation and root mass (Tables 2 and 3) typical of each variety of soil showed that a varied vegetation is characterized by a dissimilar chemical composition. We note a basic difference in the relationship between the content of easily mobile substances and difficulty decomposed lignin. According to Kononova (7), cellulose and substances extractable by benzene-alcohol and also hemi-cellulose and proteins are, first and foremost, related to amount of easily mobile substances.

Table 2

Chemical composition of surface vegetation in % of absolutely dry ash-free matter

Soil	Water-soluble organic matter	Substances extracted by alcohol-benzene	Hemi-cellulose	Cellulose	Proteins (Nx6.25)	Lignin residue	Total	Ratio of easily mobile substances to lignin
Light sierozem	5.49	2.89	12.12	40.00	11.53	4.38	76.41	16.3
Dark sierozem	6.17	3.52	13.29	44.95	7.05	8.23	83.21	19.2
Cinnamon-brown carbonate	10.03	5.54	8.53	29.94	8.12	9.73	81.89	7.4
Cinnamon-brown typical	10.78	4.10	7.89	32.25	4.67	9.98	69.67	6.0

We see from the data in Tables 2 and 3 that the greatest quantity of mobile substances is found in the vegetative mass of light sierozem, The lignin group, on the other hand, increases from light sierozem to cinnamon-brown typical soil. Thus, the chemical composition of vegetation confirms the conclusions which we have drawn earlier (5) (based on studying the intensiveness of organic matter decomposition of the various soils) that the humification of plant residue in light sierozem takes place more intensively than in cinnamon-brown typical soil, while the dark sierozem and cinnamon-brown carbonate soil occupy in this respect an intermediate position.

The organic matter of light sierozem is characterized by a very great dynamism — humification of plant residue and subsequent mineralization of formed humus place in it more rapidly than in other soils. This is also confirmed by the microbiological data of Zakharchenko (4) who established that, by the amount of bacteria in one gram of organic matter in the soil, light sierozem is first among all soils of Tadzhikistan. Owing to this, the humus content in light sierozem is maintained at a constant level (of an order of 25 metric tons per ha in a 0-20 cm layer). Therefore, light sierozem, despite a comparatively low content of humus, is a highly fertile soil on which cotton yields, the highest in the world, are obtained during properly organized crop rotation under irrigation and continuous organic matter enrichment conditions.

Qualitative humus characteristics of the basic soil groups of Tadzhikistan. We see that in the various soils of Tadzhikistan, as a result of different climatic conditions, character and amount of vegetation etc., there is an unequal accumulation of humus both in intensity of process and in absolute quantity of matter participating in it. A study of humus has shown that, by its qualitative composition, the soils of Tadzhikistan not only differ among one another, but differ as a whole from the other soils of the USSR. This is already clearly seen in the content of nitrogen in humus. We see from Table 4 that the soils of Tadzhikistan are generally characterized by a high content of organic nitrogen. The value of the ratio C:N in all soils studied does not reach 10, whereas

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[1] The method for the biochemical analysis of vegetation drawn up by N.P. Bel'chikova has been taken from Kononova's book (7).

Table 3

Chemical composition of roots[a] in % of absolutely dry ash-free matter

Soil	Water-soluble organic matter	Substances extracted by alcohol-benzene	Hemi-cellulose	Cellulose	Proteins (Nx6.25)	Lignin residue	Total	Ratio of easily mobile substances to lignin
Light sierozem	3.26	3.72	13.97	19.58	10.46	22.89	73.88	2.2
Dark sierozem	3.62	3.53	12.77	17.40	9.90	19.55	66.77	2.4
Cinnamon-brown carbonate	3.57	4.18	14.25	16.98	7.37	27.65	74.00	1.7
Cinnamon-brown typical	4.29	4.48	11.48	14.84	11.18	31.26	77.53	1.5

[a] Roots have been taken from soil at depth of 0-20 cm.

Table 4

Humus and nitrogen content in percent of soil

Soil	Depth, cm	Humus	Nitrogen	C:N
Light sierozem	0—20	1.08	0.154	4.2
Cinnamon-brown carbonate	0—20	3.65	0.350	6.0
Cinnamon-brown typical	0—20	6.20	0.490	7.4
Cinnamon-brown light	0—20	7.29	0.495	8.5
Cinnamon-brown dark	0—16	10.40	0.658	9.2
High mountain forest under juniper	10—30	6.68	0.476	8.1
Mountain meadow typical	0—15	7.56	0.588	7.5
Mountain meadow peaty	0—30	9.26	0.658	8.1
High mountain sod meadow	0—20	4.97	0.476	6.0

in most other soils of the USSR, according to Tyurin's data (9), the ratio of C:N exceeds this figure.

In examining Table 4, it is easy to see also the quite specific inverse relationship of the value of the ratio C:N to the quantity of humus in the soil. The humus of soils with low humus content are the richest in nitrogen (C:N is equal to 4.2 in light sierozem; 6.0 in cinnamon-brown carbonate and high mountain sod meadow soils). As the quantity of humus increases, the ratio of C:N becomes increasingly wider. The humus of light sierozem is characterized by an especially large relative content of nitrogen. This is caused, evidently, in the first place, by the fact that the plasma of microorganisms is of great importance as the general source of humus formation when vegetation is scantly, and, in the second place, by the great intensiveness of the humus mineralization processes, which is an obstacle to the accumulation in this composition of highly-molecular carbonic compounds.

To a still greater degree the qualitative difference in the humus of the soils studied is revealed and also their difference from the other soils of the USSR, when examining the group composition of humus. We made a study of the group composition according to the present generally-accepted scheme of I. V. Tyurin. We repeatedly extracted humic substances soluble in 0.1 N NaOH of all fractions to the point of obtaining almost colorless extractions. The results of the determinations are found in Table 5.

The differences in the group composition of humus of the soils studied, as seen from Table 5, are expressed chiefly in the varied content of the basic groups composing humus — the humic acids and fulvic acids.[2] Attracting

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[2] We are conditionally placing in the group of "fulvi acids" all substances which remain in the acid soluti after precipitation of humic acids from an alkaline extract.

Table 5

Group composition of humus

Soil	Depth, cm	Humus	Total carbon	Percent of total carbon					
		% of soil		Carbon of substances soluble in a alcohol-benzene mixture	Carbon of hydrolyzate 1.0 N H_2SO_4	Carbon of humic acids			
						Fractions[a]			
						I	II	III	IV
Light sierozem	0–20	1.08	0.63	7.8	10.8	5.4	7.8	5.4	2.5
Ordinary "	0–20	1.65	0.96	—	11.8	—	21.8	3.9	2.1
Dark sierozem	0–20	2.55	1.48	6.1	9.7	8.5	12.4	5.5	2.4
Cinnamon-brown carbonate	0–20	3.65	2.12	5.0	6.7	14.7	4.9	5.3	3.6
Cin. -br. typical	0–20	6.20	3.60	5.3	6.6	12.8	5.7	3.6	2.7
Cin. -br. light	0–20	7.29	4.23	5.9	3.8	8.7	2.1	3.8	1.5
Cin. -br. dark	0–16	10.40	6.03	4.1	2.5	11.8	16.2	3.6	1.9
High mountain forest	10–30	6.88	3.87	4.7	3.1	2.0	7.8	2.2	1.5
Mountain meadow typical	0–15	7.56	4.38	7.4	3.4	13.0	0.0	Not det'd	1.1
Mtn. mead. peaty	0–30	9.26	5.35	7.4	4.9	8.2	6.9	4.5	1.0
High mountain sod meadow	0–20	4.97	2.88	Not det'd.	2.0	3.9	4.5	2.9	1.6

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[a] Alkaline extract: Fraction I before decalcification of soil; Fraction II after decalcification; Fraction III after treatment of soil with 0.1 N sulphuric acid with five hour's warming (heating).

attention is the fact that among the given soils we do not see the pattern established by Tyurin (10), namely, a change in the content of the humic acid group in direct relationship to total humus content in the soil. On the other hand, we note the smallest values in the ratio of humic acids to fulvic acids in the more humified soils (the cinnamon-brown light, high mountain forest, mountain meadow typical, mountain meadow peaty). The principal humus mass in them is represented by fulvic acids. By this, it seems that we can explain the discrepancy, incomprehensible at first glance, between the high humification of these soils and their comparatively light color.

The fulvic acid group is predominant in all the soils examined (except the cinnamon-brown dark soil); fulvic acid content in all cases is at least 33%, and in the high mountain soils reaches 51%-54%. This characteristic feature and also the small value of the nonsoluble residue of humic substances (18%-7%) sharply distinguishes the soils of Tadzhikistan from the other soils of the USSR.

The cinnamon-brown dark soil occupies a special place; by its high humification (10.4%), predominance (although little) of the quantity of humic acids over fulvic acids, and also by nitrogen content in humus, which is lowest of all (Table 4), cinnamon-brown dark soil differs noticeably from the other soils of Tadzhikistan and reveals a certain similarity with the soils of the chernozem group.

A characteristic of the humus of all soils described is the presence in it of a group of substances soluble directly in acid (0.05 N HCl). Tyurin considers that this group is represented by fulvic acids associated with available ferric and aluminum hydroxides (10). We found this group to contain 3%-14% humus (by carbon) in all the soils studied including sierozems — the light, ordinary, and dark, and also cinnamon-brown soils, which disagrees with Tyurin's data, according to which these substances are missing in sierozem and cinnamon-brown soils. The presence of these easily-soluble substances increases the availability of the organic matter of soils and its activity in the mineral destruction processes.

The fractional composition of humic acids and fulvic acids also indicates the great availability of humus in the soils of Tadzhikistan.

Table 5 continued

Percent of total carbon								Humic acids / Fulvic acids	Carbon residue	Total
Total carbon of humic acids	Carbon of substances soluble in mineral acids (1.0 to 0.05 N HCl)	Carbon of fulvic acids				Total carbon of fulvic acids				
		Fractions[a]								
		I	II	III	IV					
21.1	6.0	18.7	0.0	9.4	5.1	33.2	0.64	20.8	99.7	
27.8	3.1	29.7	—	2.8	2.1	34.6	0.80	21.6	—	
28.8	6.1	17.2	0.0	8.0	5.0	30.2	0.95	20.2	101.1	
28.5	5.5	25.4	2.0	3.7	1.9	33.1	0.86	21.8	100.5	
21.8	5.6	27.3	2.8	1.9	1.2	33.2	0.75	22.7	98.2	
16.1	3.8	27.8	8.5	8.8	2.4	47.5	0.34	19.0	96.1	
33.5	9.8	24.0	1.2	6.3	0.0	31.5	1.06	19.1	100.5	
13.5	12.0	36.8	5.6	8.1	0.9	51.4	0.26	16.1	100.8	
14.1	12.3	29.0	10.6	Not det'd.	1.0	40.6	0.35	15.5	—	
20.6	6.8	36.6	1.7	13.0	0.5	51.8	0.40	8.0	99.5	
12.9	Not det'd.	27.3	15.7	8.3	2.7	54.0	0.24	13.8	—	

Tables 6 and 7 present data showing the relative distribution within these groups of their various fractions — by degree of stability of their relationship to the mineral part of soil, and, consequently, by degree of their availability.

As we can see from Table 6, the humus of all soils studied includes in its composition a fraction of humic acids, soluble directly in weak alkali (Fraction I). According to Tyurin (11) this fraction is represented by brown humic acids in a free state, and, in the form of humates, of di- and trivalent metals. We note a particular predominance of brown humic acids in the group of cinnamon-brown soils (except the cinnamon-brown dark). More typical of the sierozems is Fraction II — the black humic acids, non-soluble directly in 0.1 N NaOH, but Fraction I in them amounts to 25%-30%. The cinnamon-brown dark soil is also distinguished here from the other

Table 6

Fractional composition of humic acids in Tadzhikistan soils in % of the total amount of humic acids

Soil	Fraction			
	I	II	III	IV
Light sierozem	25.6	37,0	25.6	11.8
Ordinary sierozem	78.4		14.1	7.5
Dark sierozem	29.3	42.9	19.3	8.5
Cinnamon-brown carbonate	51.7	17.0	18.7	12.6
Cinnamon-brown typical	52.1	22.8	14.5	10.6
Cinnamon-brown light	54.2	13.0	23.6	9.2
Cinnamon-brown dark	35.2	48.4	10.7	5.7
High mountain forest	14.8	57.8	16.3	11.1
Mountain meadow peaty	30.8	33.5	21.8	4.9
High mountain sod meadow	30.2	34.9	22.5	12.4

Table 7

Fractional composition of fulvic acids in Tadzhikistan soils in % of total quantity of fulvic acids

Soil	Fraction			
	I	II	III	IV
Light sierozem	56.4	0.0	28.3	15.3
Ordinary sierozem	85.9		8.1	6.0
Dark sierozem	57.0	0.0	26.5	16.5
Cinnamon-brown carbonate	76.9	6.2	11.1	5.8
Cinnamon-brown typical	82.3	8.4	5.7	3.6
Cinnamon-brown light	58.5	17.9	18.5	5.1
Cinnamon-brown dark	76.2	3.8	20.0	0.0
High mountain forest	71.7	10.8	15.8	1.7
Mountain meadow peaty	70.7	3.3	25.1	0.9
High mountain sod meadow	50.6	29.1	15.3	5.0

varieties of its group; in this soil Fraction II of humic acids predominates which, again, in some measure, draws this soil toward Chernozem soil, humus of which, according to Kononova's data (7) includes humic acids associated primarily with calcium in the form of humates nonsoluble in 0.1 N NaOH.

Fractions III and IV, represented as humic acids, associated with relatively stable sesquioxide hydrates, form in all soils studies, a small part of their total content (not more than 25%-35%).

A large part of the fulvic acids (from 50%-80%) are evident in Fraction I — available easily-soluble compounds found in a free state or in a state not stably associated with soil (Table 7).

Several other humus properties of the soils of Tadzhikistan. The optical density of the humic acids of several soils of Tadzhikistan were determined according to the method described by Kononova (7). Both Kononova and Bel'chikova (1) conducted a determination with seven light or color filters having wave-lengths of 726, 665, 619, 574, 496 and 465 mμ, using the universal photometer, FM model not on the Pul'frikh spectrophotometer. The preparations of humic acid — sodium humate solutions, were carefully equalized according to their carbon content; in all of the solutions the carbon content was equal to 0.136 g/l; the thickness of the liquid layer in the cell was equal to 1 cm. The FM photometer scale gives readings for the values: τ the filtration coefficient and D optical density which is the logarithm to the base 10 of the value of reciprocal τ

$$(D = -\lg\tau)$$

Thus, the data obtained has been expressed directly in units of optical density. The results of the determinations are given in Table 8 and in Figure 1.

Humates of cinnamon-brown dark soil and of ordinary sierozem have the highest optical density; humates of high mountain soils and cinnamon-brown light soil have the lowest optical density. Humates of light sierozem occupy an intermediate position.

The cinnamon-brown dark soil is also separated here; the high optical density of its humates again confirms the closeness of its humus properties to the humus of chernozem.

M. M. Kononova considers (7) that the high optical density of humates is an indicator of the high condensed state of the aromatic nucleus. Proceeding from this, we can draw the conclusion that this characteristic is least expressed in the humic acids of high mountain soils, where there obviously prevail side chains that determine a higher degree of dispersion, than in the humic acids of sierozem. This, it seems, corresponds to reality, if we consider that high mountain soils develop under conditions of far greater moisture that prevents the formation of molecules with a complex condensed nucleus. It is interesting that light sierozem, despite its very low moisture, also has a comparatively low optical density of humates. This again emphasizes the specific humus characteristic of light sierozem — its high dynamism, constant or continuous "rejuvenation" (restoration) as a result of rapidly occurring formation and decomposition processes, which exclude conditions for "aging" and the complications of the molecules of substances forming it.

Table 8

Optical density D of humate solutions

Soil	Depth, cm	Value of D with wave length (mμ) of						
		726	665	619	574	533	496	465
Light sierozem	0—20	0.35	0.49	0.61	0.74	0.99	1.37	1.64
Ordinary sierozem	0—20	0.44	0.62	0.78	1.02	1.38	1.77	2.26
Cinnamon-brown dark	0—30	0.43	0.64	0.82	1.13	1.49	1.99	2.50
Cinnamon-brown light	0—20	0.19	0.26	0.36	0.46	0.72	0.98	1.18
Mountain meadow peaty	0—30	0.23	0.31	0.42	0.53	0.75	1.02	1.32
High mountain sod meadow	0—20	0.22	0.32	0.43	0.52	0.66	1.05	1.32
High mountain forest	10—30	0.26	0.36	0.45	0.56	0.85	1.23	1.45

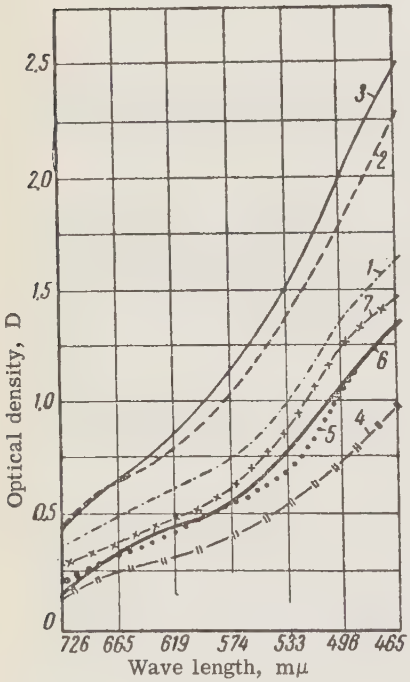

Fig. 1. - Optical density of humate solutions.

1 - light sierozem; 2 - ordinary sierozem; 3 - cinnamon-brown typical soil; 4 - cinnamon-brown light; 5 - mountain meadow peaty; 6 - high mountain sod meadow; 7 - high mountain forest soil.

Determining the coagulation (precipitation) threshold of humates, of several soils confirmed the conclusions which had been drawn based on a study of their optical properties. From Table 9, where data is found on determinations conducted according to Bel'chikova's (1) method, we see that the difference in resistance to coagulation (precipitation) among the humates of various soils corresponds to the differences among them according to their optical properties.

From the four soils studied, the humates of ordinary sierozem and of cinnamon-brown dark soil (Fig. 1, curves 2 and 3) have the least resistance to coagulation (precipitation). Humates of high mountain forest soil (curve 7) coagulate (precipitate) with greater difficulty — only with a concentration of an electrolyte equal to 30 meq per one liter of humate solution. Humates of cinnamon-brown light soil, which have the lowest optical density (curve 4) begin to coagulate (precipitate) and then very slightly, only with a concentration of 40 meq of $CaCl_2$ per one liter, but their complete coagulation does not take place at all under these conditions.

Thus, these data confirm the previously-stated condition of a greater degree of dispersion of the humic acids of high mountain soils than of ordinary sierozem and cinnamon-brown dark soils.

In conclusion, we may note that the differences among soils of various groups and varieties are clearly seen in the qualitative and quantitative composition of their organic part. One of the principal factors of humus accumulation in soil is the amount of vegetation under which a given group of soil varieties are developed and also the qualitative composition of this vegetation.

The absolute value of humus reserve is greatest in soil where the greatest plant mass is being developed, while the relative intensiveness of its accumulation depends considerably upon the character of vegetation and chemical composition of its surface and root mass. Thus, ephermeral vegetation on light

Table 9

The coagulation (precipitation) threshold of humates

Soil	Depth, cm	Beginning of coagulation		Total (complete) coagulation		Remarks
		Time, hours	$CaCl_2$ meq/l of humate	Time hours	$CaCl_2$ meq/l of humate	
Ordinary sierozem	0—20	immediately	15	1 2	20 15	
Cinnamon-brown dark	0—30	"	12	1.5 2	40 12	
High mountain forest	10—30	(slightly turbid)	30	3	30	Following complete coagulation the solution remains slightly colored.
Cinnamon-brown light	0—20	"	40			No complete coagulation.

sierozem, which contains in its composition a large percentage of easily mobile substances, is a more intensive source of humus than the abundant vegetation of mountain soils, which is more difficult to subject to decomposition.

The most typical properties of their humus common to most of the soils of Tadzhikistan studied, are: 1) A high relative content of nitrogen; 2) Presence (and in certain cases a very marked one) in the humus composition of mobile forms — groups of substances soluble directly in weak alkali, and also a small quantity of insoluble residue. These indicators indicate the high mobility of humus and its active participation in the soil-forming processes; and 3) Predominance of substances incorporated under the name of "fulvic acids" over humic acids.

This last characteristic especially distinguishes the soils of Tadzhikistan; it is typical that no direct relationship between quantity of humic acids and total humus content is observed here. We observed the greatest content of the group of "fulvic acids" in the high humified mountain soils, which are developed under high moisture and relatively low temperature conditions.

Besides such a community of certain properties, the organic matter of the soils studied has several differences, which are quite clearly seen in studying group composition, optical density of the solutions of the basic components and their ability to coagulate. A factor which determines these differences is the vertical zonality in the distribution of these soils, which is responsible for unequal conditions in their development.

Cinnamon-brown dark soil occupies a special place among the soils described; most of the properties of its organic matter sharply distinguish it from all the other soils of this series and, as it seems to us, resemble soils of the chernozem group. This soil requires a special, more detailed study in order to obtain exhaustive data for explaining its special place among the other soils of Tadzhikistan.

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BIBLIOGRAPHY

1. BEL'CHIKOVA, N. P. 1951. Patterns of humus composition and properties of humic acids. Trudy Pochvennogo Instituta im. V. V. Dokuchayeva Akad. Nauk. SSSR. Vol. 38.

2. GRABOVSKAYA, O. A. 1958. Soil of the central part of the Turkestanskiy mountain range. Trudy Akad. Nauk. Tadzh. SSR. Vol. 73.

3. GRABOVSKAYA, O. A., and P. A. KERZUM. 1957. Soils of the cotton growing districts in Tadzhikistan. Trudy Akad. Nauk. Tadzh, SSR. Vol. 79.

4. ZAKHARCHENKO, A. F. 1957. Microflora of basic soil groups and varieties of Tadzhikistan. 1957 manuscript. Fondy Instituta Pochvovedeniya Akad. Nauk. Tadzh. SSR.

5. ILOVAYSKAYA, N. N. 1951. Organic matter of the soils of southern Tadzhikistan. Trudy Akad. Nauk. Tadzh, SSR. Vol. 1.

6. KERZUM, P. A. 1954. Processes in the development of the basic soil groups of southern Tadzhikistan. Doklady Akad. Nauk. Tadzh, SSR. No. 10.

7. KONONOVA, M. M. 1951. The soil humus problem and present-day problems in studying it. Izd. Akad. Nauk. SSSR.

8. KUTEMINSKIY, V. YA. 1958. Soils of the Obi-Khingou River Basin. 1958 manuscript. Fondy Instituta Pochvovedeniya Akad. Nauk. Tadzh, SSR.

9. TYURIN, I. V. 1949. Geographic patterns of humus formation. Trudy yubil. sessi, posvyashch, stoletiyu so dnya rozhdeniya V. V. Dokuchayeva. Izd. Akad. Nauk, SSSR.

10. TYURIN, I. V. 1951. Several results of research on the study of humus composition. Trudy Pochvennogo Instituta im. V. V. Dokuchayeva Akad. Nauk. SSSR. Vol. 38.

11. TYURIN, I. V. 1951. Analysis method for studying soil humus. Trudy Pochvennogo Instituta im. V. V. Dokuchayeva Akad. Nauk. SSSR. Vol. 38.

RECENT INVESTIGATIONS ON SOIL HUMUS IN JAPAN

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Soil scientists of all nations are showing great interest in humic acids. The concept of "humus" is becoming increasingly clear; however, many unresolved problems still remain concerning the chemical nature and structure of humus substances and the formation of their functions in soil. To resolve these problems, studies have been made in several European countries (Soviet Union, Germany, England, etc.). Numerous studies of humus substances have been made in Asia by Japanese soil scientists. A study of soil humus presently occupies an important part in the soil science of Japan.

The present article gives a brief historical review of soil humus studies conducted in Japan.

Investigations of the Humus Problem before 1940

A scientific study of soil was begun in Japan at the beginning of the Twentieth Century. During the initial stage of soil science development in Japan, Suzuki (50) published a study on the problem of humus formation from several well-known organic compounds. Moreover, he studied various forms of humus nitrogen and determined the amino-acid composition of the hydrolyzates of humic acids.

During the period from 1900-1910, Aso and Imai (2) studied the organic matter of several soils using the methods of Schreiner and Shorey (46), and in the 1920's and 1930's many authors (e. g., Osugi and Sano (41), Ito (19), and Hosoda (7)) used methods that had been worked out by Waksman and his colleagues (56). Almost simultaneously Kawamura (24) studied the adsorption of bases by humic acids obtained from sugar during boiling with inorganic acids. Tokuoka (52) first used the polarographic method for studying humic acids and attempted to examine the components by measuring their decomposition potential. Saeki (43) also used the physico-chemical methods for studying humus and clay complexes which were precipitated from mixtures of humic acid solutions and solutions of Fe^{+++}, Al^{+++} (or SiO_3'' at an isoelectric point).

The German school, represented by Simon, Springer, and Hock, had a great influence on humus studies in Japan during the 1930's and 1940's. The methods they proposed and their concepts are presently being used by several Japanese investigators.

Several Remarks on the Soils of Japan. According to Kamoshita (20) the principal zonal soil groups (principal soil groups) of Japan are represented by podzols, brown forest soils, and red soil (similar to red earths), which are dominated by brown forest soils, differing from ordinary brown earths (in the sense of German and American scientists) by its acidic character.

Thus, the zonal soil groups are characterized by a small diversity or variety, which makes it practically impossible to study geographic patterns of humus formation.

In addition, among the intrazonal soils two specific groups are distinguished; one belongs to the moisture soil group, according to Stremme's classification, and is being used for rice cultivation. These "paddy" (inundated) soils are divided into two subgroups. The wet paddy-soils are inundated over the course of an entire year, while the dry paddy soils are characterized by somewhat deeper ground waters and only in the summer during the rice cultivation period are they flooded, whereas during other seasons they are drained for wheat, barley, vegetable, etc.

Typical of the paddy soils are the reduction processes caused by irrigation; the dry paddy soils reveal a very typical profile with an illuvial horizon containing iron and manganese and also a gley horizon.

Another specific group of intrazonal soils are the so-called soils of volcanic origin.

These soils originate from relatively recent volcanic ash and usually have a very acid reaction. As basic minerals of a clay fraction they contain allophane and aluminum hydroxide. Among the volcanic soils are distinguished a subgroup usually called the "Kuroboku" or "Kuroonzhi" (the "Ando soil" of American authors) which is characterized by a very high humus content and black color. The soils of this group cover a fairly large area; however, they are not usually highly productive, because of high acidity and large quantities of free aluminum.

Besides the soils just mentioned, we encounter in the north-east section of Japan peat soils and dark-colored soils rich in humus. In the following account which shows the previously-indicated separation of soils in Japan, we shall touch upon humus investigation of paddy soils and of soils developed on volcanic ash. In the Soviet Union and in Germany, humus studies are being conducted from the zonal aspects, i. e. by calculating the bioclimatic factors of soil formation; in Japan, it is impossible to discuss humus studies apart from the specificity of soil use and the character of parent material (bedrock formation).

Studies of the Humus Problem after 1940

A Study of Humic Acid Fractions. Hayashi (9) studied several humic acids extracted from various soils using the methods of Springer (48) and Hock (13). The results obtained were for the most part, similar to the data of Springer and Hock. The most important and specific results were obtained for humic acids from the volcanic soils.

Hayashi extracted from humic volcanic soil, humic acids which, by method of separation, correspond to the gray humic acids of Springer. These acids are considerably darker than the gray humic acids and are associated with Al and Fe, while the gray humic acids are associated with calcium. Considering their specific character, he called these acids "black humic acids." Another peculiar feature of these acids is the low nitrogen content with a high carbon content — the ratio of C:N usually within the limits of 20-40. Thus, black humic acids 1) may be considered as highly-humified products, denoted by their black color, or 2) they may be regarded as a matured humus substance, considering the high value of the ratio C:N and the relatively high content in them of acetylbromide soluble organic matter. These inconsistent characteristics of black humic acids, as Hayashi supposes, were caused by the specific character of the soil-forming processes, occurring in the soils on volcanic ash with their high acidity and microbiological conditions differing from the normal.

Kobo (25) employed the Simon method (47) in order to study the humus formation process in the recently cultivated humus soils on volcanic ash. He confirmed the fact that, as the soil becomes more mature, its content of so-called decomposition products and fulvic acids decreases, while the content of "true humic acids" increases and reveals the tendency towards stabilization.

Kumada (32) also used the Simon method for studying humus in paddy soils and showed that the humus of dry paddy soils belongs to a later stage of humification than the humus of wet paddy soils. Kumada (33) in a later work, established that the absorption spectrum of the humic acid solution is its most essential feature and based on these spectra, he made a broad study of the various forms and properties of humic acids.

Plotting on the ordinate the values of log K (K — the extinction coefficient) and on the abscissas the wave length within limits of 220-700 mμ for 0.01% of humic acids in an alkaline solution, Kumada (33) adopted the value log K_{600} as the optical density indicator and found for slope of curve the value Δ log K = log K_{400} — log K_{600}. For the values of log K_{600} and Δ log K, an inverse ratio was found similar to that established by German investigators.

Proceeding from the assumption that a decrease in the value Δ log K indicates an intensification of humification, Kumada arranged soils according to the value Δ log K and set up, thusly, the following relationships between types of soil and the value Δ log K.

Type	Subtype	Δ log K	Soil species
A	A_1	about 0.50	Humus soils on volcanic ash with a low content of exchangeable bases.
	A_2	about 0.55	Soils rich in exchangeable Ca
B	B_1 ~	0.6 0.7	Alluvial soil, dry paddy soil
	B_2 ~	0.7 0.8	Alluvial soil, wet paddy soil
	Rp[a] ~	0.8 1.0	Peat

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[a] Rp — decomposition products.

The designations A, B, and Rp originate from terms used by Simon. However, in the case cited above, the shape of the absorption spectra curves is a distinctive feature of type A, as compared with type B, whereas in Simon's method stability with respect to the Mg ion is used in separating these types. The convex shape in the ultra-violet part of the curve is peculiar to type A, while the shoulder or arm-shaped absorption band near 275 mμ from which the upward part of the curve ascends sharply towards the short-wave portion of the spectrum, is peculiar to type B. Kumada arrived at the conclusion that the A and B types of humic acids are related to various polymeric homologs and that the value Δ log K is an indicator of the extent of polyermization of each homologous subtype.

These soils are arranged according to the shape of the spectral curve and value of Δ log K, i. e. extent of humification agrees well with the patterns of changes in these properties of humic acids, such as elementary composition, capacity towards exchange, content of hydrolyzable nitrogen, sensitivity to electrolytes, etc.

Based on data in the elementary composition of humic acids, Kumada concluded that the humification process consists of two stages. The first is the joining of nitrogen to organic matter having a low nitrogen content (possibly to lignin-like substances) simultaneously with a decreased carbon content and a lowered ratio of C:N. In the dry paddy soils, this process reaches its highest expression. In the second stage the nitrogen content in humic acids gradually decreases and, consequently, carbon content again increases. During this process, as the author supposes, the ability to absorb light, that is, the dark color of humic acids, may be intensified.

Next, Kumada showed with the aid of X-ray analysis that humic acids with a high degree of humification reveal a structure similar to amorphous carbon, which becomes more evident according to degree of humification. Recently he studied the absorption spectra of humic acids in infrared light, and suggested that: 1) the separation into types A and B is also confirmed by the character of the spectra; 2) humic acids consists of different aromatic and aliphatic compounds; and 3) the aromatic nature of humic acids becomes increasingly noticeable as humification is intensified and also increased is the intensity of bands dependent upon, or caused by oxygen-containing groups.

Summarizing experimental results, Kumada attempts to substantiate the following conclusion regarding the formation and accumulation of soil humus. Type A humic acids are formed from the polymerization products of phenolic compounds, which originate from microbe metabolism products, while their stabilization and accumulation in soil are realized by combination with polyvalent cations. In addition type B humic acids are derived primarily from lignin. Lignin in the soil decomposes preserving its own basic structure wherein gradually the ex change products of microbes are included; as a result humification leads to formation of type B humic acids. Thus, type B humic acids differ from type A by nature of formation processes; however, it is supposed that under certain conditions a transformation of the first type into the second becomes possible.

Of great interest is the fact that the data obtained by Kumada coincides in many respects with Kononova's data (29) and that of other Soviet investigators.

Of great interest are the studies by Hayashi and Nagai (10), who used the chromatography method for fractionation of soil humic acid components obtaining at the same time very important results. These authors divided humic acids extracted from several soil species into types A and B according to Simon's method and studied these extracts by chromatography on paper and in a column (the adsorbent is active aluminum oxide). They used alkaline solutions as developers and examined chromatograms under an ultra-violet light.

Using this method, all humic acids were divided into three or four components designated as fractions I, II, III and IV according to the position they occupied on the chromatograms, i. e., Fraction I is the most mobile, while fraction IV is the least mobile. These investigators conducted a comparative study of such properties of these fractions as absorption spectra and nitrogeneous composition. Their results are as follows.

1) The degree of humification of all humic acids corresponds to the series I< II< III< IV and this sequence was observed for the optical density and content of nonhydrolyzable nitrogen.

2) Types A and B of humic acids consist for the most part of common components while the differences between these two types (capacity to be precipitated by Mg-ions and tinge of coloring) depends, it seems, upon the quantitative content of the components. Quantitative determinations of these components show that the most humified fractions (III + IV) are predominant in type A humic acids, while fractions (I + II) predominate in type B.

Kasaka and others (30) attempted to show the relationship between the basic soil groups of Japan and the humic acid forms found in them, using for this purpose the methods of Simon (47), Moodie's hypo-iodide method (34), Springer's sulfoacetolysis (49) and also the determination of uronic acids and methoxylic groups.

Hosoda and Takata (16) made a study of humus in soil from Daysen (a famous volcano in western Japan) proceeding from the fact that the most important part of humuc consists of the so-called lignin-humus complexes of Waksman. During recent years these authors have ascertained the chemical structure of humic acids. In addition, they have attempted to derive the aromatic substances of lignic origin by ethanolysis and oxidation by nitrobenzene. They have confirmed the presence of vanillic, lilac-colored and other acids even in the humic acids which characterize a later stage of humification.

Studies of the Fulvic Acids Fraction. Typical of all countries is the inadequate number of studies devoted to these acids. The chromatographic method proposed by Forsyth (4) was used on a large scale. In Japan, Hosoda and others (17) used this method to study the humus of soils developed on volcanic ash. Yamane (57) showed that the so-called β — fraction of Waksman is none other than a complex compound of fulvic acids with aluminum.

Recently, Kobo and Tatsukawa (28) described a method for obtaining an extract of colored substances from a fulvic acid fraction by ethanol extraction and subsequent purification by ester and acetone. They obtained extracts from various soils and made a comparative study of their properties: elementary composition, X-ray diffraction, absorption spectra in ultra-violet light, and also in visible and infrared portion of the spectrum, etc. Their conclusions are as follows: The nature of fulvic acids in various soils varies very little and, generally speaking, these acids are similar in structure to those humic acids which are the lowest stage of humification. These conclusions are very interesting in the light of ideas recently developed by Kononova (29) according to which fulvic acids are the lowest forms of humic acids (considering this latter group as more highly-molecular compounds).

Humus and the Mineral Fraction of Soil. The Tyulin method (53) is the best known method in Japan for studying the relationship between humus and the mineral fraction. Harada and others (6) used this method for studying paddy soils and showed that paddy soils contain a larger amount of electro-negative gels (g_1) than isoelectric gels (g_2); a large part of the humus in g_1 gels are represented by brown humic acids. Hosada and Takata (15) used this method for studying the humus of soils taken from the Daysen volcano and found that the g_2 content was higher than the g_1. In both cases, however, they did not succeed in determining the relation between g_1 content and soil fertility, despite Tyulin's directions.

Kobo and Fujisawa (26) conducted studies of synthesized complexes consisting of humus and clay. They showed that humic acids adsorbed on clay minerals reveal under certain conditions a higher degree of humification.

Kasaka and Iseki (31) studied different humate solution curves and arrived at the conclusion that humus in the basic soil groups of Japan is associated with sesquioxides.

Kawaguchi and Kyuma (23) used the method proposed by Tyurin (54) for determining humus composition in order to study paddy and humus soils on volcanic ash. They showed that the basic part of humus soluble in alkali from an unstable relationship with sesquioxides.

Recently, Harada (7) showed that 0.1 N solution of borax dissolves free humic acids in like manner as Al and Fe humates, but not Ca humates. With several solvents, including the borax solution, he studied the humus composition of several soil groups. Studies of the humus of soil on volcanic ash have also confirmed the possibility of combining humic acids with trivalent cations. Moreover, they showed that the ratio of humic acids to fulvic acids soluble in borax and pyrophosphate corresponds, or someqhat exceeds, a similar value obtained for chernozem.

Okuda and Hori (38) subjected Simon's method to criticism in separating the true humic acids from decomposition products and showed that combining them with iron or aluminum has an effect on the solubility of true humic acids with a pH of 4 (acetate buffer).

Recently, Okuda and Hori (40) proposed a new method for preparing a water solution of humic acids. For this purpose, an alkaline or neutral salt solution of humic acid was passed through a column with an anion-exchangeable resin in OH-form, and then through a cation-exchangeable resin in H-form. The solution thus obtained has an acid reaction (a pH of 2-3 depending upon the concentration) but, none the less, the humic acids are present in it in a highly dispersed state.

In the humus solution prepared by this method Kawaguchi and Kyuma (22) using the potentiometric-titration method confirmed the formation of a complex (chelate) between humus and polyvalent cations (ca, Al, and Fe). They came to the conclusion that the precipitation of humic acids was dependent upon the formation of a complex between polyvalent cations and humus particles containing a developed aromatic nucleus.

Egawa and Sekiya (3) studied the role of humus in the formation of soil structure and proposed that humic acids are responsible for the formation of primary fine aggregates while the soluble humus, including fulvic acids, cause the formation of larger secondary aggregates.

Humus and the Nitrogen Problem. As has already been pointed out above, Kumada (33) and also Hayashi and Nagai (10) established that the nonhydrolyzable nitrogen content increases with humification. Kobo and others (27) obtained similar results in studying nitrogen in soil organic matter.

Using the paper chromatography methods Okuda and Hori (37) and also Hayashi and Nagai (10) studied the amino-acid composition of hydrolyzates of humic acids, determining 15 types of these acids. Using the same method, Harada (8) found 15 various amino-acids in a fulvic acid fraction and showed that the amino-acid composition in both cases is the same.

Practically the most important problems associated with humus nitrogen are the mineralization of nitrogen in paddy soils and its use by rice. Harada and other investigators (5) studied organic nitrogen mineralization conditions and showed that the "soil drying effect" of Shioiri and Aomine (44) the "effect of increasing soil temperature" of Shioiri (45), etc., are especially important. The first of these factors is of the greatest practical importance and the designation itself of "effect" stems from the fact that more ammonium nitrogen is formed when irrigating paddy soil after air-drying, than when irrigating initially uncultivated (not dried) soil. These authors showed that easily decomposed organic matter, which is the chief cause of the effect, is included in the fraction of g_1 gels, whereas the g_2 gels become sources of the second of these effects, which is caused by an increase in soil temperature during flooding of the soil.

Humus and the Phosphorous Problem

After publication in 1904 of Aso's first works (1) on organic phosphorus, many authors devoted themselves to a study of this problem; however, owing to lack of space, we cannot examine these studies here.

While nitrogen is practically the most important for ordinary soils, the phosphorous problem is of the greatest importance for soils on volcanic ash, because of the high content in these soils of free aluminum (and iron) which combine to a large extent the phosphorus. Besides the soils developed on volcanic ash, large areas of plowed land are covered with soils which have a more or less expressed allyl character and, consequently, carrying out measures aimed at increasing the available forms of phosphorus in these soils is an urgent problem.

Noda and Saio (35) showed that humic acids interact with sesquioxide hydrates, forming several kinds of humates, thereby preventing the phosphorus from being fixed. Moreover, the humic acids, to a certain extent, intensify the hydrolysis of the difficulty-soluble phosphates precipitated thereby making phosphorus in a more available form.

Okuda and Hori (39) showed that organic matter decomposition increases phosphorous absorption, while addition of humic acids creates the opposite effect.

Several Methods Available for Studying Humus

Let us examine several methods which have been used recently in studying humus.

Okuda and Hori (36) have shown that the colloidal titration methods introduced by Terayama (51) may be used for studying humic acids. The principle involved is, namely, that with various values of pH, positive or negative colloidal ion charges are determined by titration by an oppositely charged standard colloidal solution, using as the indicator the metachromatism phenomenon of such a dye as toluidine blue. These authors obtained by this means relatively accurate humic acid titration curves reflecting the differences among humic acid properties.

This method was next used by Otsuka and Nagata (42) and also by Hayashi and Nagai (11) in studying humus substances while examining mixed systems, consisting of humus substances and mineral colloids. This method was used by Kashiwagi and Yokoi (21) and Hayashi and Nagai (12). The results obtained from these studies are not particularly important and merely confirm the data established by the other methods. Nevertheless, this method may prove useful for future studies, especially of humus-clay systems.

The differential thermal analysis method (DTA), usually used for studying clay minerals is also appropriate for the study of soil humus. Iri (18) obtained DTA curves for humic acids and noted the presence in them of one endothermic and two exothermic peaks.

Wada and Hirotsu (55) studied, using DTA, the powdered air-dried soils and found many exothermic peaks caused by an organic fraction within the limits 250-550°C. The DTA curves of organic matter of ordinary and cultivated paddy soils reveal exothermic peaks in the low temperature zone, while soils on volcanic ash show more intensive peaks in the temperature range above 450°C. These authors ascribe the presence of allophane in these soils as the cause of this phenomenon.

Conclusions

This article has presented a review of soil humus studies being conducted in Japan. Our purpose was to show the specific nature of these studies and to discuss those results which may be of interest to scientists abroad.

We express our sincere hope that research by our colleagues, in close collaboration with investigators abroad, will contribute to resolving humus problems.

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BIBLIOGRAPHY

1. ASO, K. 1904. Bull. Coll. Agr. Tokyo Imp. Univ., v. 6, 277.

2. ASO, K. and S. IMAI. 1919. Bull. Imp. Centr. Agr. Exp. Stat., (J), No. 41, I, 1916; No. 43, 34.

3. EGAWA, T. and K. SEKIYA. 1956. Soil and Plant Food, Tokyo, v. 2, 75.

4. FORSYTH, W. G. C. 1947. Biochem. J., v. 41, 176.

5. HARADA, T. 1951. et al. J. Sci. Soil and Manure, Japan, (J), v. 19, 93, 95, 1948; v. 20, 72, 1949; v. 21, 153, 1950; v. 22, 149.

6. HARADA, T. 1954. et al. Soil and Plant Food, Tokyo, v. 1, 49, 105, 1955; J. Sci. Soil and Manure, Japan, (J), v. 21, 155, 1950; v. 23, 196, 217, 1952; Sci. Bull. Fac. Agr. Kyushu Univ., (J), v. 13, 116, 1951; The Symposium on the Soil Fertility, (J), Tokyo, 1954.

7. HARADA, M. 1957. Soil and Plant Food, Tokyo, v. 1, 3, 1955; v. 2, 35, 1956; v. 3, 73.

8. HARADA, T. 1957. Trans. Congr. Sci. Soil and Manure, Japan (J), No. 3, 10.

9. HAYASHI, T. J. 1943. Fac. Agr. Tottori Univ., v. 1, 1, 125, 135; 1951—3; J. Sci. Soil and Manure, Japan, (J), v. 15, 290, 1941; v. 16, 206, 1942; v. 17, 300.

10. HAYASHI, T. and T. J. NAGAI. 1958. Fac. Agr. Tottori Univ., v. 3, 55, 97, 105, 1955-1956; Soil and Plant Food, Tokyo, v. 2, 171, 1957; J. Sci. Soil and Manure, Japan. (J), v. 24, 212, 1953; v. 25, 285, 1954; v. 26, 371, 1955; v. 27, 305, 1956; Trans. Congr. Sci. Soil and Manure, Japan, (J), No. 4, 8.

11. HAYASHI, T. and T. J. NAGAI. 1957. Sci. Soil and Manure, Japan, (J), v. 28, 369.

12. HAYASHI, T. and T. J. NAGAI. 1958. Sci. and Manure, Japan (J), v. 29, 153.

13. HOCK, A. 1938. Bodenkunde u. Pflanzenernähr., Bd. 2, 304, 1937; Bd. 5, 1, 1937; Bd. 7, 99.

14. HOSODA, K. 1938. Mem. Tottori. Agr. Coll., (J), v. 6, 1.

15. HOSODA, K. and H. J. TAKATA. 1953. Sci. Soil and Manure, Japan, (J), v. 24, 65.

16. HOSODA, K. and H. J. TAKATA. 1958. Sci. Soil and Manure, Japan (J), v. 24, 70, 153, 1953; v. 27, 498, 1956; v. 28, 64, 1957; Trans. Tottori Soc. Agr. Sci., (J), v. 11, 1, 1956; Trans. Congr. Sci. Soil. and Manure, Japan, (J), No. 3, 14, 1957; No. 4, 8.

17. HOSODA, K. et al. 1957. J. Sci. Soil and Manure, Japan, (J), v. 28, 23.

18. IRI, H. 1956. Soil and Plant Food, Tokyo, v. 2, 33.

19. ITO, H. J. 1929. Sci. Soil, and Manure, Japan, (J), v. 3, No. 1, 51.

20. KAMOSHITA, V. 1955. Soil and Plant Food, Tokyo, v. 1, 99.

21. KASHIWAGI, H. and H. J. YOKOI. 1953. Sci. Soil and Manure, Japan, (J), v. 24, 25.

22. KAWAGUCHI, K. and K. KYUMA. unpublished data.

23. KAWAGUCHI K. and K. J. KYUMA. Sci. Soil and Manure, Japan, (J), (in preparation).

24. KAWAMURA, J. J. 1926. Phys. Chem. v. 30, 1364.

25. KOBO, K. 1949. Bull. Physiograph. Sci. Res. Inst. Tokyo Univ., (J), No. 2, 1.

26. KOBO, K. and T. J. FUJISAWA. 1958. Sci. Soil and Manure, Japan, (J), v. 25, Supplem. v. 1, 37, 1954; Trans. Congr. Sci. Soil and Manure, Japan. (J), No. 1, 23, 1955, No. 2, 13. 1956; No. 3, 12, 1957; No. 4. 10.

27. KOBO, K. et al. 1957. Trans. 6th Int. Congr. Soil Sci., B, 485, 1956; J. Sci. Soil and Manure, Japan (J), v. 24, supplem. 1, 2, 1953; Trans. Congr. Sci. Soil and Manure, Japan, (J), No. 2, 10, 1956; No. 3, 11, 1957.

28. KOBO, K. and R. TATSUKAWA. 1958. Trans. Congr. Sci. Soil and Manure,

Japan, (J), No. 4, Supplem. 3, 1958; No. 4, 4.

29. KONONOVA, M. M. 1958. Die Hummusstoffe des Bodens. Berlin.

30. KOSAKA, J. et al. 1956. Soil and Plant Food, Tokyo, v. 1, 59, 1955; v. 2, 59, 142, 1956-1957; J. Sci. Soil and Manure, Japan, (J), v. 21, 279. 1950; v. 22, 209, 1951; v. 23, 57, 279, 1952; v. 24, 79, 1953, v. 26, 376, 1955; v. 27, 435.

31. KOSAKA, J. and A. ISEKI. 1956. Soil and Plant Food Tokyo, v. 2, 8.

32. KUMADA, K. J. 1950. Sci. Soil and Manure, Japan, (J), v. 20, 45, 1949; v. 21, 171, 318.

33. KUMADA, K. et al. 1958. Soil and Manure, Japan, (J), v. 3, 148, 152, 1958. Bull. Physiograph Sci. Res. Inst. Tokyo Univ. (J), No. 9, 6, 1951; J. Sci. Soil and Manure, Japan (J), v. 25, 217, 263, 1954; v. 26, 5. 97, 179, 231, 287, 1955. v. 27, 79, 119, 175, 1956; Agriculture and Horticulture, (J), v. 33, 873, 1019, 1163, 1333, 1487.

34. MOODIE, C. D. 1950. Soil Sci., v. 70, 461.

35. NODA, M. and K. J. SAIO. 1954. Sci. Soil and Manure, Japan, (J), v. 24, 141, 1953; v. 25, 13. 173.

36. OKUDA, A. and S. HORI. 1952. Mem. Res. Inst. Food Sci. Kyoto Univ. (J), No. 9, 24.

37. OKUDA, A. and S. HORI. 1955. Soil and Plant Food Tokyo, v. 1, 39.

38. OKUDA, A. and S. HORI. 1956. Soil and Plant Food, Tokyo, v. 2, 42.

39. OKUDA, A. and S. HORI. 1957. Soil and Plant Food, Tokyo, v. 2, 195.

40. OKUDA, A. and S. HORI. unpublished data.

41. OSUGI, S. and Y. J. SANO. 1929. Soil Sci. and Manure, Japan, (J), v. 3, No. 4, 1.

42. OTSUKA, K. and T. J. NAGATA. 1952. Soil Sci. and Manure, Japan (J), v. 23, 69.

43. SAEKI, H. 1939. Mem. Fac. Sci. Agr. Taihoku Imp. Univ., v. 25, I, 1939.

44. SHIOIRI, M. and S. AOMINE. 1940. Bull. Imp. Centr. Agr. Exp. Stat., (J), Extra ed.

45. SHIOIRI, H. 1943. The Chemistry of Paddy Soils, (J), Tokyo.

46. SCHREINER, O. and E. SHOREY, et al. 1909. J. Amer. Chem. Soc. v. 30, 1295, 1599, 1908; v. 31, 116 v. 32, 1674, 1910; v. 33, 78, 81, 1412, 1911; U. S. D. A. Bur. Soils Bull. No. 53, 70, 74, 77, 80, 83, 89, 90, 108.

47. SIMON, K. und H. SPEICHERMAN. 1938. Bodenkunde und Pflanzenernähr, Bd. 8, 129.

48. SPRINGER, U. Z. 1938. Pflanzenernähr., Düng., Bodenkunde, A. Bd. 22, 135 1931; A. Bd. 23, 1, 1932; A. Bd. 34, 1, 1934; A, Bd. 45, 327, 1936; Bodenkunde und Pflanzenernähr., Bd. 6, 312, 1938.

49. SPRINGER, U. 1953. Bodenkunde und Pflanzenernähr., Bd. 32, 129, 1943; Z. Pflanzenernähr., Düng, Bodenkunde, Bd. 60, 285, 1953.

50. SUZUKI, S. 1907. Bull. Coll. Agr. Tokyo Imp. Univ., v. 7, 95, 419, 513.

51. TERAYAMA, H. 1949. Chem. Res., (J), v. 1, 75, 1948; v. 4, 31, 1949.

52. TOKUOKA, M. and K. Z. RUZICKA. 1934. Pflanzenernähr., Düng., Bodenkunde, A. Bd. 35, 79, 1934.

53. TYULIN, A. F. 1938. Soil Sci., v. 45, 343.

54. TYIRIN, I. Y. 1951. Trudy Pochv. Inst. Dokuchaeva, v. 38, 5.

55. WADA, M. and T. HIROTSU. 1958. Trans., Congr. Sci. Soil and Manure, Japan, (J), No. 3, 13, 1957; No. 4, 64, 1958.

56. WAKSMAN, S. et al, 1930. Soil Sci., v. 22, 221, 1926; v. 24, 275, 317, 1927; v. 30, 97.

57. JAMANE, J. 1954. Soil Sci. and Manure Japan, (J), v. 25, 207.

CHARACTERISTICS OF THE FAUNA OF BOG FOREST SOILS OF THE CENTRAL TAIGA

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This article presents data obtained from three years of field studies (1955-1957) conducted by the Laboratory of Forested Bog Research of the Forestry Institute, Academy of Sciences, USSR in the Kadnikovskoye Forest Area, Vologda Oblast', and partly in Arkhangel'sk Oblast'. The data obtained give a fairly good description of the fauna of the bog soils of the central taiga. It is well known that soil fauna has a considerable influence on the decomposition of organic matter and on the physical properties of the soil. We studied the quantitative and qualitative composition of the invertebrate animals in soils from different types of bog forests in order to solve the problem of their role in the process of peat formation.

We made some changes in the method of our work (4), i.e., we decreased the size of each individual sample of microfauna[1] and increased the number of samples. Roundworms were separated by the Eglitis method (9); in this case the volume of the samples reached 80 cm³. About 100 samples were taken for microfauna and 50 samples for mesofauna from each type of soil. Excavations for mesofauna were taken down to the water table.

The studies showed that the great mass of microfauna are adapted to life in the upper 10 cm of the soil. Thus, we give their count in a 10-cm layer of one square meter area.

According to P'yavchenko's data (6), the bog forests of the European part of the Soviet Union can be divided into three ecological series, or series of bog formation: drained, slightly drained, and stagnant.

The drained bogs are distinguished by soils with the highest ash content, low acidity, and a high saturation of the soils with bases. Under the conditions prevailing in the eastern part of the central taiga, fir forests mixed with birch, undergrowth of deciduous shrubs, coarse bog-grasses, and a varied moss cover are most characteristic for this series. Well decomposed lowland peat is developed here. A stand of fir with coarse bog-grass was studied as a representative of this series.

The conditions for the existence of organisms in forests of the drained bog type are marked by their uniqueness. These conditions are: variability of wetness, the richness of the soils in calcium, and the relatively good oxygen regime brought about by drainage.

The fauna that inhabit the soils of the drained bog series are of a mixed nature and consist of soil and fresh-water animals. A part of these fresh-water animals probably migrated to living in hydrogenic soils (4).

The soil animals we found here (earthworms, enchytrae) can withstand temporary floods of water enriched with oxygen (8). They are most active during dry periods when their numbers increase two or three times. At such times the fresh-water fauna are maintained by the high moisture content of the peat. During long wet periods the activity of the soil fauna is decreased. Fresh-water fauna, of which the Oligochaeta and the Chironomidae are the most important in decomposition processes, are developed in flooded lowlands, According to our studies, the mass of these animals, represented by the large species, reaches 34 g/m². This quantity shows that they plan an important role in the decomposition of the litter on which they feed.

The soil microfauna of fir stands of the bog-grass group consists of diptera larvae, Enchytrae, roundworms, ticks, and springtails. The mesofauna are represented by earthworms, the larvae of beetles, diptera, and myriapods. The total number of the soil fauna usually does not reach a great size (Table 1). It is approximately twice the total number in a pine forest with shrubs and peat moss. However, the biomass of the most important soil formers is

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[1] The terms mesofauna and microfauna are used in the sense employed by M.S. Gilyarov (2).

Table 1

Group composition of the soil fauna complexes in different types of bogs
Number per square meter of surface

Name of group	Type of bogs		
	Drained	Slightly drained	Stagnant
	Fir stand with coarse bog-grass	Fir stand with sphagnum moss	Pine stand with shrubs and sphagnum moss
Enchytrae	1370	2000	2340
Earthworms	16.6	per one hummock	—
Springtails	633	4400	1560
Diptera larvae	1831	484	72
Beetle larvae	5.2	50	5
Ticks	1067	560	660
Roundworms	1421	—	—
Myriapods	4	6	
Fresh-water animals, molluscs (pisidium	300	—	
Oligochaeta	500	—	
Diptera larvae	1250	—	
Total	8440.6	7500	4639

large and may be said to compensate for the lack in numbers (Table 1). Moreover, the great diversity of the groups of these animals ensures more thorough and rapid decomposition of organic matter from the first stages up to the formation of high-grade humus, as a result of the earthworm activities.

The data presented above on the food of the different groups, families, and species of animals were taken from data in the literature (1, 3, 7, 11–20). The pulverization of the litter and its initial decomposition is due to diptera larvae (Tipulidae, Tabanidae, Chironomidae), beetles and myriapods. A part of the representatives of these groups are predatory. More complete decomposition of organic matter with subsequent synthesis is due to the humus-forming group (16), which includes earthworms, Enchytrae, springtails, roundworms, and ticks in the soils described here. The basic role here belongs to earthworms, which occupy first place in bio-mass.

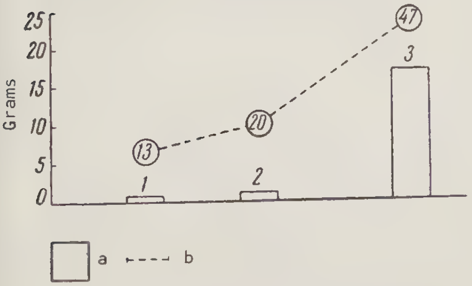

FIG. 1. - The connection between the bio-mass of soil fauna and the degree of peat decomposition.

a - bio-mass; b - degree of peat decomposition (1 cm = 10%).

Earthworms feed on fresh and decomposed litter and on the excrement of other animals. Enchytrae and roundworms eat decomposed vegetable residues with preference for deciduous and grassy vegetation. Bacteria, amorphous organic residues, and fungus mycelia serve as food for springtails. The food of some diptera larvae from the Licoriidae and Limnobiidae is similar to that of the preceding group.

Ticks and their nymphs feed on fresh and fallen, decomposed deciduous and coniferous litter, and on algae. Chironomid larvae absorb organic matter in different stages of decomposition, the spores and mycelia of fungi, etc. Fresh-water Oligochaeta utilize different organic residues and algae as food. Thus, the decomposition processes of organic substances are distinguished by considerable diversity in the drained bog series.

The slightly drained series is marked by poorer, quite acid soils with a small degree of base saturation. The forest cover may consist of fir, birch, and pine. The undergrowth in the forests of this series is poor in the number of species, and the cover is essentially represented by peat (sphagnum) mosses with a mixture of grasses with rigid leaves and stems (sedges, rushes, and horsetails). The soils are sphagnum peat with a moderate degree of decomposition, and with a high moisture content throughout the entire year.

We studied a fir stand with a peat moss cover as a representative of this series. Seasonal frost is retained for the longest period in this forest type. The dominant group of soil animals here is the springtail group, followed by the Enchytrae, then the ticks. The quantity of diptera larvae and, in particular, roundworms is insignificant. The studies showed that the Enchitrae and springtails are of smaller size than in the preceding type of forest. The mesofauna includes practically no earthworms – the important factor in soil formation. The mesofauna are represented by myriapods and beetle larvae.

The diversity of food chains for the animals is less here than in soils of the drained series. Pulverization and initial decomposition of vegetable residues is essentially done by myriapods while the role of diptera and beetle larvae is considerably smaller.

Of the three families of diptera found here, two are predatory (Rhagionidae and Dolichopodidae) and only one (Tipulidae) participates directly in processing vegetable litter; ticks and their nymphs eat fresh litter and decomposed residues. The most complete decomposition of organic matter and the formation of humus is due to the activities of Enchitrae and springtails. However, the bio-mass of the microfauna is so insignificant that one can scarcely speak of it as having an important role in the destruction of organic matter in slightly drained bog soils.

Forests with soils that are poorest in ash, acid, and slightly saturated with bases are those forests in the stagnant bog series. Only one species of trees is represented – the pines. The ground cover consists of peat mosses. The top layer of soil is formed from slightly decomposed sphagnum peat. A stand of pine with shrubs and peat moss was studied as the forest type belonging to the stagnant series.

The distinctive features of the soil fauna were the lowest total number and bio-mass, and the small diversity of groups. The Enchytrae were dominant in respect to total number, followed by the springtails, then the ticks. The springtails and Enchytrae were also marked by their small size.

The mesofauna, which was very poor, included no earthworms; there were small quantities of diptera, beetle, and myriapod larvae. Both the small numbers and the small diversity of groups provided evidence of the insignificant role of soil fauna in the decomposition of organic matter in this type of forest. Determination of the bio-mass of Enchytrae, Collembola, and ticks yielded a still smaller quantity than for the slightly drained series (Fig. 1). The high moisture content and other unfavorable factors connected with it restrict the development and activity of soil fauna.

It should be noted that a large total number, diversity, and a considerable bio-mass of soil animals is characteristic of drier types of forest. In bog soils the development of soil animals is characterized by its irregularity. It is usually hampered in the spring and summer by the high moisture content and reaches its culmination by autumn. Thus, the period of intensified plant growth does not coincide with intensified decomposition of organic matter.

A comparison of the soil fauna of these forest types shows that the smallest total number and bio-mass are characteristic of soils of the undrained bog type. The small diversity of animal groups does not ensure the natural decomposition sequence of organic matter from its initial stages to the more complex stages. In addition, the soil is flooded periodically with stagnant water during the summer on account of rains. This disrupts the activities of the soil fauna, gives it an irregular character, and decreases the number of days in which this activity takes place. Enchytrae and springtails are most important here in the decomposition of organic matter.

The high soil moisture, its poor aeration and increased acidity also have an unfavorable effect on its microflora. According to Benade's summary (10), the soils of the upper bogs are poor in microflora; they contain insignificant amounts of organisms which decompose proteins and cellulose; they lack nitrate formers, but have considerable amounts of denitrifying bacteria. Peat formation takes place in the upper, aerated horizon and is of a temporary character (5).

Soils of the drained series are distinguished by a larger total number of animals and, which is particularly important, a larger bio-mass. The total quantity of animals in soils of the drained series is about twice that of stagnant series and the bio-mass about thirty-five times as great. Consequently, the possibilities of biogenic decomposition of organic matter are increased many times in the drained series. The diversity of the soil groups ensures their participation in different stages of the decomposition process – from the initial stages to the formation of humus by earthworms. The upper layers of lowmoor peat are less wet than those of highmoor peat, which ensures better conditions for the activity of the animals (85%-87% against 91%–93%). The variability of the water regime causes irregularity in the activity of the soil invertebrates; nevertheless, the decomposition process of vegetable residues does not cease during wet periods owing to the continuity in the activity of soil and freshwater animals. The principal role in the decomposition of organic matter is played by Oligochaeta and diptera larvae. The degree of decomposition of peat reaches 50%–60% here.

The more favorable environment, which consists of lower wetness, greater aeration, and richness in calcium, also has a good effect on the microflora of these soils. An increase in the total number and the quantity of groups of animals living in the soil has been noted (10); in particular, nitrate formers and nitrogen-fixers appear.

Soils of the slight drainage type occupy an intermediate position in respect to their fauna. In spite of the fairly large numbers of animals, the food chains are considerably less diverse here than in the drained series. Small quantities of mesofauna are observed, and as a result, earthworms which are encountered in hummocks are practically excluded from the soil-forming process. Springtails comprise the cominant group. Owing to the high soil moisture, the activity of soil fauna is of an irregular character.

In conclusion, it is necessary to state that the different complexes of soil animals in bog forests do reflect the specificity of the ecological conditions which can be used successfully in the classification and evaluation (of the forest cover) of bog soils (2). The biological activity increases as one passes from the stagnant to the drained series of water-logging. This is reflected in an increase in the total number and the diversity of the groups of microflora and soil fauna, an increase which is reflected in turn by an improvement in the decomposition of organic matter.

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BIBLIOGRAPHY

1. GAVRILOV, K. A. and T. S. PEREL'. 1958. Earthworms and other invertebrates in the soils of the forests of Vologda Oblast'. Pochvovedeniye, No. 8.

2. GILYAROV, M. S. 1949. The classification and geography of soils in the light of soil zoological studies. Uspekhi sovremennoy biologii, Vol. 28, No. 3 (6).

3. ZRAZHEVSKIY, A. I. 1957. Earthworms as as a factor in soil fertility. Kiev.

4. KOZLOVSKAYA, L. S. 1957. The fauna of the forest soils of the Kotlas Forestry Enterprise. Tr. In-ta lesa, Vol. 36.

5. KURBATOVA-BELIKOVA, N. M. 1954. The results obtained from study of the microbiological activity in natural peat beds. Tr. In-ta torfa. Vol. 3.

6. P'YAVCHANKO, N. I. 1956. Experiment in the classification of bog forests. In the collection: In honor of Academician V. N. Sukachev on the occasion of his 75th birthday). Izdatel'stvo Akad. Nauk SSSR.

7. SOKOLOV, D. F. 1957. Importance of millipedes and ants in the transformation of organic matter in forests planted under the conditions of the dry steppe. Biol. Mosk. o-va ispyt. prirody, otd. biol. Vol. 62 (5).

8. CHUGUNOVA, M. N. 1957. Survival of certain species of earthworms in water. Uch. zap. Ped. in-ta im. Potemkina, Vol. 65, No. 6.

9. EGLITIS, V. K., 1954. Fauna of the Soils of the Latvian SSR.

10. BENADE, W. 1954. Mikroflora der Moore. Wien, Frankfurt a/M, (In German).

11. BRAUNS, A. 1954. Terricole Dipteren-Larven. Berlin. (In German).

12. DUNGER, W. 1956. Untersuchungen ueber Laubzersetzung durch Collembolen. Zool. Jahrb. Abt. Syst., Bd. 84, N. 1. (In German).

13. DUNGER, W. Ueber die Zersetzung der Laubstreu durch die Boden - Makrofauna im Auenwald. Zool. Jahrb. Abt. Syst. Bd. 86, H. 1. (In German).

14. DUNGER, W. 1958. Ueber die Veraenderung des Fallaubes im Darm von Bodentieren Z. Pflanzenernaehr., Dueng, Bodenkunde, Bd. 82, H. 2/3. (In German).

15. GRAFF, O. 1953. Bodenzoologische Untersuchungen mit besonderer Beruecksichtigung der terricolen Oligochaeten. Z. Pflanzenernaehr. Dueng. Bodenkunde, Bd. 61, H. 1. (In German).

16. FRANZ, H. 1955. Die Bedeutung der Kelintiere fuer die Humusbildung. Z. Pflanzenernaehr. Dueng. Bodenkunde, Bd. 69, H. 1 - 3. (In German).

17. FROEMMING, E. 1956. Quantitative Untersuchungen ueber die Bedeutung bodenbewohnender Landschnecken fuer den Abbau des Fallaubes. Biol. Zbl., Bd. 75. (In German).

18. KUEHNELT, W. 1955. Bodenbiologie. Wien, 1955.

19. MURPHY, P. 1955. Ecology of the Fauna of Forest Soils. Soil Zoology. (In English).

20. SCHUSTER, R. 1956. Der Anteil der Oribatiden an den Zersetzungsvorgaengen im Boden. Z. Morphol. und Oekol. Tiere. Bd. 45. (In German).

TYPES OF ANAEROBIC PROCESSES IN THE CENTRAL BARABA PEATS

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Successful cultivation and use of bog soils depends a great deal on the proper regulation of aerobic and anaerobic processes in them. Therefore, a knowledge of the development patterns of these processes in bog soils is a present problem.

There is very little data on the bogs of the Central Baraba describing the dynamics of the aerobic and anaerobic processes. Verner and Orlovskiy (2), examining the ground waters of virgin bogs, established the absence in them of oxygen and the presence of hydrogen sulphide and an active microflora of anaerobic sulphate-reducing bacteria. As a result of this and subsequent research the idea arose that desulfurzation is the chief anaerobic process in the bog soils of the Baraba.

Studying soil air on drained bogs, Sokolovskaya (8) determined that the oxygen content n it during the time of observations did not drop below 19% which indicates the predominance of aerobic conditions. However, she managed to obtain actual samples of soil air only during high aeration of peat. Therefore, he composition of soil air of less aerated horizons remained unstudied.

Observations on the oxidation-reduction poential (ORP) in the bog soils of the Karapuzskoye flood plains (swampy depression) were conducted by Gantimurov (4). In the peat horizons of tracts of newly reclaimed bogs which e studied, high values of ORP were observed which correspond to aerobic conditions, exept in the central part of one of the tracts where n anaerobic horizon containing hydrogen sulide was revealed at a depth of 1-2 meters.

From 1954 through 1957, we conducted reguar observations for ORP on the virgin and cultivated bog areas of the Ubinskaya Experiment tation for Melioration. The weakly-solonchaklike soils of the lowland reed and sedge peat ogs were used for the study. The thickness of he peat deposit was 1.1 to 1.2 m, the degree f peat decomposition was 10%-25% in the upper horizons and up to 50%-65% in the lower horizons.

To determine ORP we used the method of Serdobol'skiy (7). Regular measurements were made at depths of 5, 20, and 40 cm. (in spring and sometimes in fall additional measurements were made at depths of 10 and 30 cm) and replicated 2-3 times. Replication was increased if large discrepancies were found among parallel determinations.

We selected as points for permanent observations typical areas of bog virgin and cultivated soils under fallow, perennial grasses and annual field crops. In the summer, observations were made approximately once a month, in the spring and fall more frequently. Once or twice a year pH in soil suspension were determined along the profile of peat deposit using a quinhydrone or glass electrode.

Besides permanent observations, single irregular determinations of ORP were made on different soils, chiefly to confirm patterns that had been found during stationary observations. Determinations of ORP in thawed-out peat horizons were always made directly in the soil. We sometimes had to take samples for measuring ORP from frozen horizons, when there was a danger of flow-in from above the permafrost surface water during direct determination.

Guided basically by literary data (6 and 7), we assumed that the value of ORP is a criterion of conditions: aerobic when its value >340 mV, anaerobic when the value <200 mV, and intermediate when the value is $200 < \mathrm{Eh} < 340$ mV. The dynamics of ORP serves as a definite indicator of the aerobic process, in the event of a substantial increase of ORP and crossing of the limit 340 mV or the anaerobic process in the event of the lowering of ORP and crossing of the limit 200 mV. Stabilization of the ORP value is proof not of the absence of the oxidizing-reducing process, but only of the advanced state of equilibrium, often of a dynamic character.

In order to show graphically the ORP regime, we have represented the Eh values for the upper half-meter of soil in the form of chronoisopleths. A picture of the dynamics represented by such means is naturally a rough sketch because of insufficient frequency of determinations. However, the basic patterns are revealed quite clearly.

Principal Features of ORP Dynamics in Bog Soils. Along the profile of soils studied we see a great variability in the value of ORP. However, at a definite depth a zone with constantly low values — less than 200 mV — begins. During our observations this zone was found to begin from a depth of 130-150 cm within limits of the gley horizon underlying the peat (Table 1). Below the zone indicated, ORP is evidently stable. Above the zone the value of ORP changes within wide limits depending on several factors. In these changes, during a considerable range of regimes of separate subjects and years which differ in annual conditions, a regular seasonal dynamics is detected. By character of ORP dynamics we can distinguish two principal periods: the spring and early summer period, and the late summer and fall period (Fig. 1).

Table 1

Oxidation-reduction potential along the profile of peat-bog soils. Eh in mV, May 9, 1956

Depth, cm	Drained virgin land		10th year of bog reclamation			
			Fallow (old plowed soil)		7-year old perennial grasses	
	Thickness of peat deposit, cm					
	120		110		120	
	Eh	pH	Eh	pH	Eh	pH
10	345	6.50	440	6.00	450	6.44
30	345[a]	6.53[a]	430a	5.96a	420[a]	5.76a
50	340[a]	6.41[a]	425[a]	6.06[a]	410[a]	5.87a
60	320	6.48	500[a]	5.83[a]	430[a]	5.75a
80	310	6.64	400	6.03	380[a]	5.72a
100	330	4.58	470	7.36	400	6.15
	mineral gley horizons					
120	260	7.15	470	6.78	480	5.79
140	325	7.66	160	6.82	160	6.82
180	170	7.58	160	7.17	140	7.67
220	145	7.49	160	7.49	120	7.60

[a] Frozen horizons

The first of these periods is characterized by more abrupt changes in ORP in time, by larger gradients along the profile, and by maximum amplitude of variation in the values from -300 to +650 mV. On virgin soil (and sometimes under perennial grasses) the development of a clearly expressed anaerobiosis is typical in the upper layers of soil during spring with excessive moisture above the nearby frozen soil. After surface drying and aeration of the upper horizon ORP increases in leaps and bounds, reaching 500-650 mV. The anaerobic conditions are preserved only above the upper limit of the frozen state. We always noted in frozen peat relatively high values of ORP (>300 mV). On most strips of cultivated bog the anaerobic conditions were usually not detected (except perennial grasses); increased values of ORP were observed in the spring aft soil drying.

The second period is characterized by mor steady changes in ORP and by lesser gradients The ORP values observed rarely exceed the limits 300-450 mV, usually being found in a more narrow range. A certain general decrease in ORP to 300-350 mV is typical during high aeration of the profile. Excessive moistu

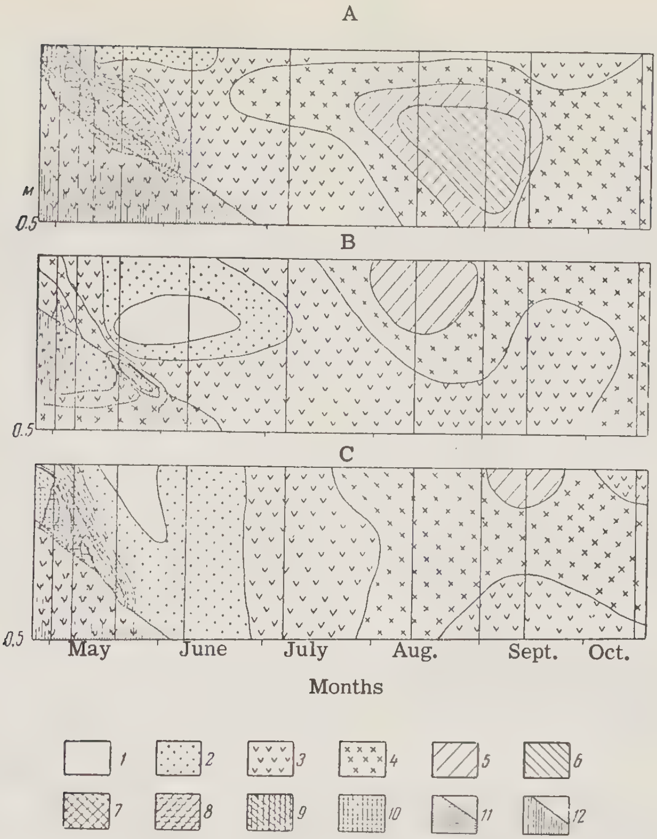

Fig. 1 - The oxidation-reduction potential regime of bog soils (1955)

A - drained virgin land, B - old-plowed strip, C - perennial grasses. Ranges of Eh values expressed in mV. 1. above 600; 2. from 500 to 600; 3. from 400 to 500; 4. from 340 to 400; 5. from 300 to 340; 6. from 200 to 300; 7. from 100 to 200; 8. from 0 to 100; 9. from -100 to 0; 10. less than -100; 11. Ground and top-permafrost waters; 12. frozen soil.

s responsible for a comparatively small re-
luction in Eh (to 100 mV, seldom below).

On the whole, after four years of observa-
ions, two wet years (1956-1957), one a year
f normal moisture (1954), and one a dry year
1955), the aerobic regime was predominant
n the bogs. Average values for the entire ob-
ervation period (See Table 2) are a proof of
his. The ORP value is, on an average, 20-40
nV higher in cultivated bog soils than in vir-
in soil.

An analysis of the data obtained supple-
nents substantially the existing ideas on the
xidation-reduction conditions of Baraba bog
oils. Generalizing, we can distinguish at
east three basic types of anaerobic processes,
hich differ not only in space and time, but
also by character.

1. Spring Surface-top of Permafrost Anaerobiosis and Factors Determining its Formation. According to Serdobol'skiy (7) the most important factors which determine soil ORP are the oxygen content in soil air and in the soil solution, as well as the products of microorganism activity. Other factors are indirect and function through the first two. However, the influence of such indirect factors (for example, soil moisture) often determines the rate of biological processes and the intake of oxygen into the soil. Therefore, as far as data permitted, we compared the dynamics of ORP with other regimes and soil properties in order to study more concretely the circumstances contributing to the formation of anaerobic processes.

Table 2

Averaged ORP regime of bog soils for the period 1954-1957.
Eh expressed in mV

Soil	Depth, cm	May 1-15	May 15-31	June	July	Aug.	Sept.	Oct.
Drained virgin land	5	270	470	420	370	370	360	390
	20	210	260	400	350	350	350	380
	40	300	150	330	310	350	300	360
Old plowed soil	5	500	540	450	410	370	400	350
	20	460	490	410	400	410	420	390
	40	390	350	410	390	370	320	400

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[a] Frozem horizons.

Soil Aeration and ORP Regime. The friable structure of the upper part of the peat layer (30-40 cm) and the low extent of peat decomposition are responsible for high soil aeration (37%-48% with moisture attaining a value corresponding to minimum moisture capacity). Therefore, in the upper horizons we may expect a deterioration of the air volume actually only during formation of subsurface water near the surface of the soil.

For the lower part of the profile where peat is more compact and decomposed, the impedance or even suspension of the air volume, according to Sokolovskaya's data (8) was observed when aeration was 16%, (i. e., judging from the moisture corresponding to the aeration value) in the lower zone of capillary fringe of ground waters.

The ground-water regime on Baraba bog, according to data of several investigators, depends entirely upon meteorological conditions. The ground-water level varies between 0 and 2 m. In average wet years, toward soil-thawing time, the level is at a depth of 50-80 cm and in the summer gradually drops to 80-100 cm. In the fall a certain rise of ground waters takes place but when freezing sets in there is a prolonged lowering of the ground-water level.

A regular and annually recurrent excessive wetting of the upper horizon of soil occurs only in the spring when the waters from the slopes enter the bog; the soil at this time is able to thaw out at 0-5 cm. As long as frozen peat is impermeable to water the top portion of permafrost surface water is formed which gradually descends following the thawing front. Total thawing of virgin bogs which have been frozen at 40-50 cm usually occurs in June, but total thawing of cultivated bogs frozen considerably deeper (to 120 cm) takes place in August and September and sometimes later. Thus, the ground waters and the frozen soil are responsible for the peculiar air exchange regime in the peat layer, which has been schematically represented in Figure 2 for drained virgin land and cultivated bog.

The free and impeded air exchange zones are kept separate in Figure 2. The second one is favorable for the development of anaerobic processes. However, the zones of actually observed anaerobiosis, although situated within limits, occupy a considerably smaller area. Thus, the impeded air exchange is a condition which is necessary but which is inadequate for the development of anaerobic processes.

Biological Activity of Soil and the ORP Regime. The principal factor for the formation of anaerobiosis is the activity of the biological processes in an excessively wet horizon.

Experiments have established that biological activity considered by intensiveness of "soil respiration" under laboratory conditions differs for the various horizons of peats and rapidly decreases downwards. The upper 0-10 cm layer is 2.5 — 4 times more active than the 30-40 cm layer.

Under field conditions these differences are greater because temperature conditions in the surface layers of peat are incomparably better than in the deep layers, especially in the spring when the soil is in a frozen state. Accordingly, there takes place in the biologically more active horizons a rapid consumption of oxygen and, whenever it is deficient, the development of the anaerobic processes and a reduction in ORP result.

Special observations have shown that the development of anaerobic processes in the spring has taken place at a specific level of biological activity of soil of the order of 100 mg and more CO_2 per 100 grams of soil during

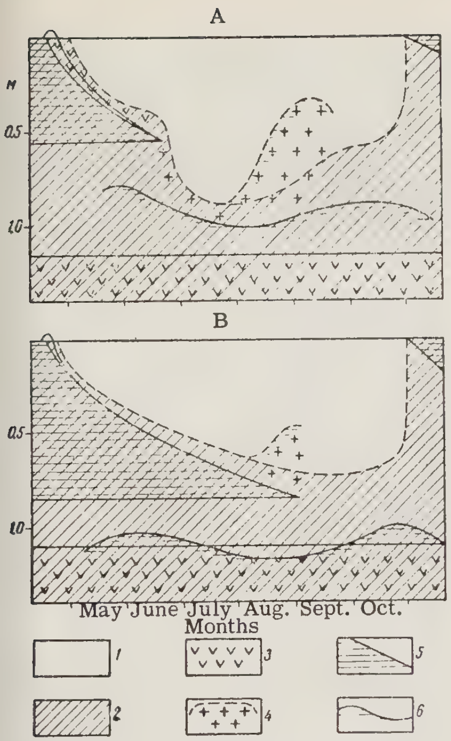

Fig. 2 - The aeration regime of peat soils and anaerobiosis (schematic)

A - Drained virgin land; B - old-plowed strip. 1. free air exchange zone; 2. impeded air exchange zone; 3. area of regular development of anaerobiosis; 4. area of episodical development of anaerobiosis; 5. frozen soil; 6. ground and suprapermafrost waters.

e first day of the experiment (CO_2 was de- ermined after Shtatnov).

These conditions were observed on the vir- in areas of bog and also on the fields under erennial grasses of prolonged use, where rge quantities of plant residue accumulated n the surface — on virgin land superficially illed since autumn, etc.[1] (Table 3).

On the other hand, on old cultivated area nder annual crops, on a fall-plowed field nd stubble, on virgin areas with specifically emoved sod where the biological activity as found reduced in connection with a lesser vailability of peat organic matter or a deficiency of it in fresh plant residue, the anaerobic processes for a comparatively short period of spring flooding were not able to be developed. We did not observe the development of anaerobiosis on newly reclaimed areas where the upper layer was plowed to a depth of 30 cm and, after thawing, was found, in the course of one or two weeks, to be in an excessively wet state. Here in the presence of a favorable substratum and rich microflora the biological processes slowed down because of low temperature which approached zero (proximity of frozen soil).

Sometimes the fallow areas were an exception. At the surface in excessively wet spring, despite a low biological activity of the soil, we sometimes observed a certain reduction in ORP (Table 3). We should note that during the period of development of the spring anaerobic processes we detected in the soil only the usual aerobic and facultative anaerobic microflora and did not find any specific obligatory anaerobic bacteria (including the sulfate-reducing bacteria).

After bog drying the upper soil horizon is aerated but, below, above the receding thawing front supra permafrost surface water is formed. Observations showed that whenever anaerobic conditions were developed in the upper horizon the value of ORP in the horizons containing subsurface water was also low, and the zone of anaerobiosis was shifted downwards following the thawing front (Fig. 3). Whenever surface anaerobiosis was not observed in the spring, it was also not observed in the suprapermafrost surface water, despite the fact that excessively wet spring and subsurface water formation were clearly expressed. This qualifies us to conclude that the upper horizon is, in this case, the source of the reduced compounds, while suprapermafrost surface water chiefly conveys the reduced substances downwards along the soil profile.

A specific spring dynamics of ORP in virgin bog soils is typical and is regularly repeated from year to year. The spring dynamics is a type of development of the anaerobic soil process. The unique nature of this type described previously is determined by the percentage of the soil process, that is, by the transformation and migration nature of substances and energy in the soil. As applied to the case on hand, the essential features of the soil process are: the short-term, but vigorous transformation of organic matter, basically of fresh plant residue, by aerobic microorganisms under oxygen deificiency conditions and the transfer of the formed available products deep into the soil with suprapermafrost surface water. Therefore, we may call the process the "spring surface suprapermafrost anaerobic soil process."

Less clear is the problem of the oxidation-

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[1] It is interesting to note that thebiological activity f the upper soil horizons is especially great in spring nd steadily declines toward summer and fall, which s evidently associated with the regime of plant resi- ue intake into the soil and by its winter freezing, hich increases availability to microbes.

Table 3

ORP, biological activity and temperature of the upper horizon of virgin and cultivated bogs during excessively wet spring

Observation date	Subject of observation	Depth, cm	Number of days from beginning of flood	Eh expressed in mV	Temperature of soil during the day, °C	Thawing, cm	Respiration of soil CO_2, mg/100 g/day
May 1, 1955	Drained virgin land	5	8	−165	5.0	16	167
		10		−10	2.0		
April 28, 1956	Perennial grasses, cirque.	1	6	−20	Not det'd.	19	151
		5		25	8.0		
		10		250	Not det'd.		
May 2, 1956	Fallow, 1954	5	10	265	9.5	21	46
		10		240	Not det'd.		
		20		220	"		
May 2, 1956	First year perennial grasses	5	10	345	12.0	19	46
		10		325	4.5		
		20		310	Not det'd.		
May 3, 1955	Fall-plowed field; Initial tillage with moldboard-	5	10	460	10.0	19	52
		10		500	4.0		
		17		500	Not det'd.		

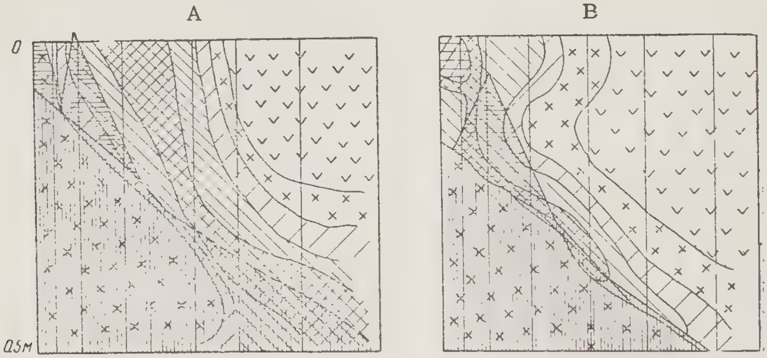

Fig. 3.- The oxidation-reduction potential regime during development of spring surface suprapermafrost anaerobiosis.

A - drained virgin land; B - perennial grasses (for symbols see Fig. 1)

reduction systems which determine the low value of ORP. The participation of organic matter — the direct products of microbiological activity is unquestionable. Sometimes we noted the presence of small quantities of H_2S. The role of Fe^{++} and Mn^{++}, it seems, is negligible. Their total content in the peat ash of these horizons is extremely small. The content of Fe^{++} in the soil solution did not exceed 0.2-0.4 mg per liter. Nevertheless, the role of anaerobiosis in this case is seen as especially important, because it is developed against a background of a peculiar downward flow of suprapermafrost surface water, which is capable of transferring along the profile substances reduced by it to an available state.

2. Summer Stagnant Anaerobic Process. The development of the anaerobic processes in summer provided an entirely different picture. These cases were observed only in 1957 which was the second wet year in succession characterized by an almost general increase in ground waters on the bogs (Fig. 4). At the same time the following patterns from

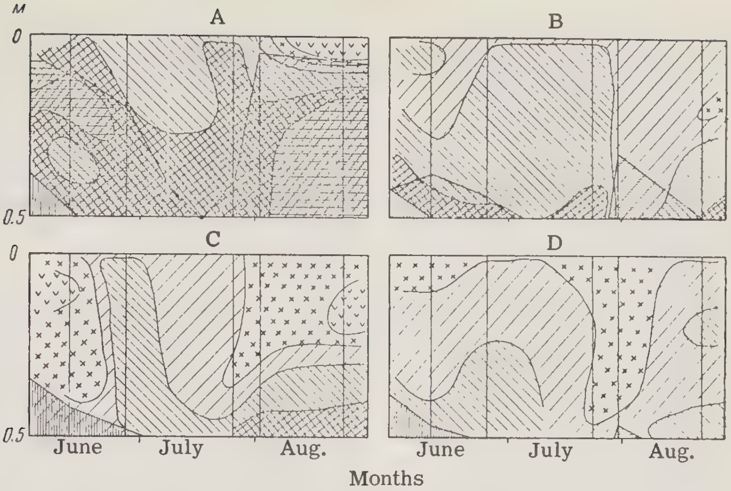

Fig. 4 - The oxidation-reduction potential regime during development of summer stagnant anaerobiosis.

A - undrained virgin land; B - drained virgin land; C - old-plowed strip; D - perennial grasses (for symbols see Fig. 1).

considerable data of permanent and single observations were noted: the absence of too low ORP values (usually >0 mV), a slower development of anaerobiosis as compared with the spring surface suprapermafrost process (of the order of weeks).

The rate and extent of ORP reduction depended mainly on the proximity of the excessively wet horizon to the surface. When the water table was near the surface (at a level of 0-22 cm) a quite vigorous reduction in ORP was observed both on virgin and cultivated areas. When the ground and suprapermafrost waters were at a greater depth (of the order of 0.5 m) Eh with rare exceptions was stabilized at the level of 250-280 mV, despite the continuously excessively wet layers virtually from the summer of the preceding year (Table 4).

The reason for this could be merely the extremely low biological activity of the deep horizons of peat deposit, composed of peat, slightly available to microbal decomposition even under optimal laboratory conditions.

Table 4

ORP of a peat layer during development of summer stagnant moisture

Depth, cm	Undrained	Drained		Rye in the cirque August 2, 1957	Oats		Perennial grasses	
	Virgin land							
	August 23, 1957	October 14, 1956	August 23, 1956		October 10, 1956	August 27, 1957	October 7, 1956	August 26, 1957
5	410	435	320	270	440	330	495	320
20	10	470	345	155	420	300	450	290
40	70	485	225	260	470	270	520	300
60	220	480	150	280	440	560	510	250
80	210	440	180	Not det'd.	390	260	520	250
100	100	380	210	"	335	280	400	270
Ground-water level	0	65	40	12	60	42	80	60

The "aeration zone" with higher ORP values (Fig. 4) was observed usually above the zone of anaerobiosis development within limits of the excessively wet part of the soil. The zone was thicker when the ground waters were deep (to 10-20 cm) and less expressed when the ground waters were high, particularly on undrained virgin land. The zone of aeration was especially increased after rain, which is proof of the important role of oxygen, which is introduced by rain water in soil aeration.

The previously described phenomena enable us to speak of a second type of anaerobiosis and to call the soil process corresponding to it "the summer stagnant anaerobic process." The type occurs during this period under stagnant excessively wet conditions, although, probably, it is accompanied by a transfer of part of the substances of the soil solution upwards during capillary rise to the surface. Its rate depends chiefly on the excessively wet layer near the surface and also, evidently on the influence of previous spring processes. With a higher ground-water level and its heating of the biologically active horizons of soil this process takes place rapidly and vigorously. When the ground waters are at a lower level, this process takes place extremely slowly and slugglishly and, possibly, is somewhat intensified, if the spring surface suprapermafrost anaerobic process precedes it. Finally, when the ground-water level is near the mineral bottom of bog, the biological processes in the excessively wet layer are found to be so slow that the diffusion of atmospheric oxygen, and, especially, its introduction with rain water guarantee the maintenance of the aerobic regime of the entire peat deposit, which was also observed in previous years.

As microbiological analyses in the excessively wet layers have shown, the usual aerobic and facultative anaerobic microflora (particularly the non-spore forming bacteria) are basically active in the summer, but the actinomycetes and certain types of fungi and cellulose bacteria are suppressed.

3. The Oxidizing-reducing Conditions of Bog Soils with Reference to Many Years' Fluctuation of Ground Waters. Not one of the types of anaerobic processes studied corresponds to that process of microbiological reduction of sulfates which was detected in the soils and ground waters of the Baraba by Verner, Orlovskiy and Gordeyeva (2, 3, and 5). Despite the fact that in several cases of spring and summer anaerobiosis we observed a precipitation of hydrogen sulfide, we were not successful in detecting in the soil horizons enveloped in the anaerobic processes the sulfate-reducing bacteria, using the method employed by Verner. At the same time, 5-8 years before, these bacteria were separated from the soil without difficulty. This enables us to confirm the fact that during the period of our studies the desulfurization process had been suppressed while the visable organism of its inducers were preserved in the soil in small quantity. We cannot, it seems, consider this phenomenon accidental because it is associated with profound changes in the water-air regime of bogs during dry years, which were brought about by intrasecular moisture fluctuations in the climate of Western Siberia, as determined by several investigators (9).

Table 5 gives the minimum and maximum ground-water levels in June-August from 1948 through 1957. We can clearly see the end of the wet period 1946-1949 with a higher ground-water level and 1950-1955, with a lower ground-water level (outside the limits of the peat deposit during a great part of the growing period). We see in 1950-51, a rapid reduction in levels while from 1956 on we see an increase in levels. These changes are directly associated with the cycle of several dry and wet years.

Our data, thus, deals with the end of the dry period, and, probably, with the beginning of the wet period. As was shown, high ORP values are typical for bog soils under these conditions. With the approach of wet years, which were 1956-57, we see a reduction in the ORP value with a lag approximately by year which indicates residual effect or reaction of the dry period.

The data of Gordeyeva (5) on the oxygen and hydrogen sulfide content in the ground waters of these same bogs for 1950-51 is proof of the anaerobic state of the lower parts of the peat layer at the beginning of the dry period, i. e. the residual effect of several wet years. According to these data, with a lowering of the ground waters in the dry year 1951, the concentration of H_2S in the ground waters reached maximum values — up to 22 mg per liter, which was not even observed in the years of greatest moisture. It seems to us that the cause of this was the discovery, during a lowering of ground waters, of the most stagnant portion of the waters at the base of the peat deposit which was under anaerobic conditions for the longest time of the previous wet period. These horizons, it seems, were also the principal seat of the development of desulfurization, from which this process under conditions favorable to it could be extended even to higher soil horizons.

The lower horizons of peat deposit are most favorable for the slow but long development of sulfate-reducing bacteria during wet years first of all, by continuous excessively wet conditions because even in these years we observe dry periods when ground waters descend in the bog to 80-100 cm. By temperature conditions the lower parts of the deposit are also more favorable to a continuous development of bacteria,

Table 5

Dynamics (of many years' standing) of the ground-water levels for a summer period (June-August) on reclaimed bog[a]

Ground-water levels	Years of Observations									
	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
Maximum	10	26	63	105	110	88	90	112	35	22
Minimum	81	106	112	145	160	135	133	151	120	94

[a] From A. R. Verner's data (scientific report of the Ubinskaya Experiment Station for Melioration for 1952), and from our observations.

because the bacteria are below the level of maximum soil freezing. The low availability of peat organic matter in these horizons, it seems, may also not inhibit such a slow development.[2] Thus, we see on the Baraba bogs the principal features of the third type of anaerobic processes, associated with deep desulfurization, which is developed in the wet phases of intrasecular cycles and which dies out in the dry phases. Associated with this process is the conception of the biogenic formation of sodium carbonate by exchangeable reaction of formed sodium sulfide with calcium bicarbonates (1 and 2). Sodium carbonate production and soil alkalinity caused by it were observed in the wet period of the 1940's, when the pH value of peat bogs amounted to 7.2-8.0.

During the drought of 1950-55, we detected considerable acidification of bog soils, which gradually extended to the entire stratum of peat deposit. In certain horizons the pH value amounted to 4.5 which excludes the presence of sodium carbonate in these horizons. A pH value of more than 7.0 was maintained only in the gley horizons underlying the peat. We associate these phenomena with a cessation of desulfurization and sodium carbonate formation, and also with acidification of existing sulfides and a new formation of humus substances of acidic character.

In connection with the peculiarity in the type of anaerobic processes examined, and its association with other soil processes, sodium carbonate formation evidently cannot bring about a progressive accumulation of sodium carbonate in the soils studied. Nevertheless, a periodic sodium carbonate formation is of great importance. Owing to it, the soil-forming process on the bog is realized alternately under medium reaction conditions, sometimes alkaline, other times acidic.

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BIBLIOGRAPHY

1. ANTIPOV-KARATAYEV, I. N. 1953. Reclamation of solonetzes in the USSR. Izd. Akad. Nauk. SSSR.

2. VERNER, A. R., and N. V. ORLOVSKIY. 1948. Role of sulfate-reducing bacteria in the salt regime of Baraba soils. Pochvovedeniye No. 6.

3. VERNER, A. R., and YE. A. GORDEYEVA. 1952. Oxygen and hydrogen sulfide content in ground waters, (subsurface waters) of the Baraba. Pochvovedeniye No. 11.

4. GANTIMUROV, I. I. 1958. Oxidation-reduction potential of peaty and peat-bog soils of Central Baraba. Byul'. Ubinskoy op. st. No. 4. Novosibirsk.

5. GORDEYEVA, YE. A. 1957. Oxygen and hydrogen sulfide content in bog waters. Byul. Ubinskoy Op. St. No. 3. Novosibirsk.

6. SERDOBOL'SKIY, I. P. 1949. Alkali-acid and oxidation-reduction conditions of plant nutrition by manganese, iron and nitrates. Trudy yubil. ses. Posvyashch. 100-letiyu so dnya rozhd. V. V. Dokuchayeva, Moscow and Leningrad. Izd. Akad. Nauk. SSSR.

7. SERDOBOL'SKIY, I. P. 1954. Methods of determining pH and the oxidation-reduction potential in agricultural-chemical studies. In the book: Agrochemical methods of studying soils. Izd. Akad.

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[2] Sulfate-reducing bacteria are not particular as to their sources of carbon nutrition and are capable of assimilating fats, wax, resin, hydrocarbons, etc. (Rubenchik. Sulfate-reducing bacteria, 1947).

Nauk. SSSR.

8. SOKOLOVSKAYA, N. A. 1955. Specific characteristics of the water-air regime of peat soils of the lowland bogs of the Baraba lowland. Author's summary of dissertation for candidates degree in Agricultural Sciences. · Pochvennyy Institut Im. V. V. Dokuchayeva Akad. Nauk. SSSR.

9. SHNITNIKOV, A. V. 1957. Total moisture variability of the mainland of the northern hemisphere. Zapiski Geogr. Obshchestva, SSSR. Vol. 16.

COMPOSITION AND ADSORPTION CAPACITY OF COLLOIDAL SEPARATES REMOVED FROM PODZOLIC SOILS BY MEANS OF THE SUPERCENTRIFUGE[1]

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This work was designed to study the composition and properties of highly dispersed separates and the effect thereon of the method of preparing the soil samples before removal of the clay particles (<0.001 mm diameter).

Two methods were utilized in preparing the soil samples before removing from them the clay separates.

In the first method a 1-kg soil sample was saturated with sodium cations by treatment with a solution of sodium chloride. After removal of the excess NaCl the soil sample was transferred to large bottles, distilled water was added to a definite level, and the contents were shaken. The upper 8 cm of the suspension, containing the particle diameters $<1\mu$, were poured off after the suspension had stood for 24 hours. Then more distilled water was added to the remaining suspension to the previous level, and the whole procedure was repeated until the decanted layer of the suspension contained practically no distinguishable particles. The decantations were repeated several tens of times, but it was not possible to achieve a completely clear decanted layer. The decantation was ended when this layer showed a slight opalescense.

In the second method, distilled water was gradually added to the soil sample until the soil assumed a paste consistency. In this consistency it was carefully triturated in a porcelain dish with a rubber-tipped pestle. After this preliminary mechanical treatment, the clay separates were isolated from the sample by sedimentation as described previously for the soil sample saturated with sodium cations.

From both suspensions containing the particles $<1\mu$ in diameter three fractions were separated by centrifugation with a laboratory tubular supercentrifuge: the first (precolloidal) was 1.0-0.2μ in diameter, the second (colloidal) from 0.2-0.05μ in diameter, and the third (colloidal) was $< 0.05\mu$ in diameter.

In working with the centrifuge we used the method suggested in the monograph of Sokolov (1). The particle diameters setting out of the suspension (on the walls of the rotor) is a function of two variables: a) the speed of the rotor, and b) the rate of adding suspension into the rotor. In addition, it depends on several constant parameters of the supercentrifuge and the suspension. This fundamental dependence can be expressed by the following equation:

$$\rho = \sqrt{\frac{v \ln \frac{R}{r_0} 9\eta}{\pi (R^2 - r_0^2) 2 \Delta \omega^2 l}}, \tag{1}$$

where ρ is the radius of the particles separated from the suspension in cm; v is the rate of adding suspension in ml/sec; R is the radius of the rotor in cm; r_0 is the internal radius of the layer of suspension in the rotor in cm: η is the viscosity of the suspersion in poises: Δ is the difference in density of the solid and liquid phases; ω is the angular velocity of rotation of the rotor in radians/sec; and l is the length of the rotor in cm.

The supercentrifuge with which we worked had the following dimensions as constant parameters: $R = 2.25$ cm; $r_0 = 0.75$ cm; and $l = 20$ cm. We took the particle density as 2.65, and that of the water was 1.0. The viscosity of the suspension was comparable to that of water. If we replace the constants under the square-root sign with the letter K, equation (1) assumes the following form:

$$\rho = \sqrt{\frac{v}{\omega^2} K}. \tag{2}$$

Starting with a suspension of podzolic soil from the Dolgoprudnaya Agricultural Chemistry Experiment Station (DACES) 1.0-2.0μ diameter particles. For this purpose, in feeding the suspension into the rotor of the supercentrifuge at a given rate we calculated the speed of revolution of the rotor at which the 1.0-0.2μ diameter particles would settle on the walls of the rotor in accordance with equation (2) and the smaller particles would remain in suspension and flow out at the upper part of the rotor. In achieving complete separation of the 1.0-0.2μ diameter particles there is also partial settling of smaller diameter particles on the walls of the rotor. These must be removed if one is to isolate the separates of the given diameter. To accomplish this, the deposited suspension was removed from the wall of the rotor and shaken in distilled water. The suspension obtained was again passed through the supercentrifuge. This operation continued until the suspension flowing from the top of the rotor became practically clear. When this had been achieved, we may assume that only particles of the desired diameter (1.0-0.2μ) are deposited on the walls of the rotor. In this way the 1.0-0.2μ diameter particles were isolated from the suspension containing particle diameters <1.0μ. The 0.2-0.05μ diameter particles were isolated in the manner described from the rest of the suspension, which contained the particles <0.2μ in diameter. In isolating this fraction the rate of feed of the suspension into the rotor was less than the previous one and the speed of revolution was higher. The particles <0.05μ in diameter (the third fraction), which remained in suspension, were flocculated with hydrochloric acid and filtered after settling. The 10.0-1.0μ diameter particles were obtained from the rest of the soil by sedimentation after separation of the particles <1.0μ.

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[1] K. I. Kurochkin took part in separating fractions.

Therefore, with each method of preparation the soil sample was separated into four fractions: 10.0-1.0μ diameters; 1.0-0.2μ diameter; 0.2-0.05μ diameter; and< 0.05μ diameter. The soil residue contained the particle diameters >10.0μ. The chemical composition of the initial soil sample and of the fractions isolated from it is given in Table 1.

The data of Table 1 show that, regardless of the method of preparing the soil sample, the content of the principal components (SiO_2, Al_2O_3, and Fe_2O_3) was similar for fractions of the same size. As the degree of dispersion of the particles increases, their SiO_2 content decreases, and their Al_2O_3 and Fe_2O_3 increases. In conjunction with this, the molecular ratio of SiO_2 to Al_2O_3 or to Fe_2O_3 decreases sharply as the degree of dispersion of the particles increases, varying in the second method of preparation (trituration) from 13.3-3.16 for $SiO_2:Al_2O_3$ and from 39.2-5.56 for $SiO_2:Fe_2O_3$. The sharpest change in the chemical composition and the molecular ratios of $SiO_2:Al_2O_3$ and $SiO_2:Fe_2O_3$ occurs when the degree of dispersion of the separates increases from the level of 10.0-1μ diameter to 1.0-0.2μ. The change is less marked when the dispersion increases from 1.0-0.2μ diameter to 0.2-0.05μ, and is still less marked from 0.2-0.05μ diameter to <0.05μ.

The TiO_2 content decreases with increasing degree of dispersion of the separates, beginning from 1.0-0.2μ diameter to< 0.05μ, regardless of the method of removing the particle diameters <1.0μ from the soil. The MgO content rises, and the CaO content decreases, as the degree of dispersion of the separates increases.

We also separated the clay fraction (using the same methods of preparing the soil) from the B horizon of a strongly podzolic soil from the Central Forest Preserve (Kalinin Oblast'). In this sample, in contrast to the first, after the removal of the clay particles from the soil saturated with sodium ions had been completed, the remainder of the soil was triturated in the paste state. Then particles <1.0μ in diameter began to separate again. From one portion of this soil the clay fraction was removed after trituration in the paste state, and from another portion, which was saturated with sodium ions. The clay fraction was first removed without triturating; and then, after the separation was finished. The remainder of the soil was triturated in the paste state, and the clay fraction was again removed. Then the clay fractions were separated into two fractions by centrifugation: 1.0-0.2μ diameters (precolloidal) and <0.2μ diameter (colloidal). The composition of the original soil, of the remaining soil after removal of the clay fractions, and of the fractions separated from the soil is shown in Table 2.

In the precolloidal and colloidal fractions, the content of SiO_2 was almost twice lower, and that of Al_2O_3 and Fe_2O_3 three and four times higher, respectively, than the content of the same constituents in the original soil. The residual soil, on the other hand, contains more SiO_2 and less Al_2O_3 and Fe_2O_3 than the original soil. In the highly disperse fractions of this sample we found a sharp increase in the P_2O_5 content as compared with the original soil and an even greater increase as compared with the residual soil. This sample showed a clearer tendency in the CaO and MgO ratios: the CaO content in the fine fractions was less, and the MgO content higher, than in the original soil. Then we determined the non-silicate forms of Al_2O_3, Fe_2O_3, and SiO_2 by the method of Jeffries both in the original soil samples and in the highly disperse fractions separated from them. We found that, as the degree of dispersion of the particles increased, more Al_2O_3, Fe_2O_3, and SiO_2 was removed from them. But the molecular ratios $SiO_2:Al_2O_3$ and $SiO_2:Fe_2O_3$ were lower than the ratio between them in the fractions themselves.

These data are explained by the fact that the Jeffries method extracts from the soil not only the non-silicate forms of the elements in

Table 1

Total chemical composition of original soil[a] and fractions isolated from it, in %

Diameter of separates, μ	Method of preparing sample prior to removal of separates <1.0 μ	Ignition losses	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	TiO_2	CaO	MgO	Molecular ratios	
											$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$
10—1	Soil triturated in paste state	5.00	73.49	14.28	5.01	9.27	0.03	0.84	1.02	1.18	13.3	39.2
1—0.2		16.06	47.52	29.56	13.38	16.18	0.10	1.17	0.93	2.22	4.94	9.47
0.2—0.05		15.07	43.85	34.73	14.61	20.12	0.10	0.80	0.94	2.64	3.66	8.06
<0.5		20.04	36.80	37.18	17.60	19.58	0.11	0.57	0.85	2.29	3.16	5.56
Soil residue after removal of particles >10		1.19	84.47	8.83	3.45	5.38	0.03	0.77	1.08	0.41	26.4	65.3
10—1	Soil saturated with sodium cations	4.86	74.19	14.53	4.35	10.18	0.06	0.74	0.74	0.92	12.0	45.5
1—0.2		12.10	52.12	28.72	11.25	17.47	0.25	1.02	0.51	1.18	5.01	12.4
0.2—0.05		13.79	44.93	33.87	12.93	20.94	0.27	0.71	0.49	1.92	3.61	9.27
<0.05		21.21	37.27	28.88	11.30	17.58	0.36	0.29	0.45	1.58	3.56	8.80
Original soil		4.27	77.02	12.05	4.79	7.26	0.11	0.72	1.03	1.19	17.8	42.7

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[a] Plow layer of soil from the Dolgoprudnaya Agricultural Chemistry Experiment Station (DACES) Sample taken from experimental field plots.

Table 2

Total chemical composition of original soil and fractions of different degrees of dispersion isolated from it, in %

Diameter of separates, μ	Method of preparing sample prior to removal of separates	Ignition losses	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	CaO	MgO	Molecular ratios	
										$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$
1—0.2	Soil trituration in paste state	10.99	46.31	35.04	18.02	17.02	0.27	0.64	2.76	4.57	6.83
< 0.2		12.06	43.84	37.03	19.21	17.82	0.34	0.42	2.25	4.13	6.06
Soil residue after removal of particles <1.0		0.55	85.16	8.26	3.41	4.85	0.02	1.12	0.55	29.78	66.35
1—0.2	Soil saturated with sodium cations	13.47	42.57	34.20	17.20	17.00	0.25	0.98	3.37	4.21	6.58
< 0.2		11.49	45.46	36.77	17.35	19.42	0.34	0.75	3.30	3.93	6.91
1—0.2	Residue of soil saturated with sodium ions, after removal of fraction <1.0 μ in diameter triturated in paste state	12.74	41.86	37.89	20.46	17.43	0.36	0.69	2.06	4.03	5.43
< 0.2		13.75	40.84	39.15	21.69	17.46	0.38	0.49	1.80	3.93	5.00
Soil residue		0.52	86.61	7.82	2.48	5.34	0.02	1.08	0.95	27.25	92.79
Original soil		2.37	79.04	12.72	3.96	8.76	0.10	0.92	1.02	15.16	53.03

Table 3

Adsorption oı Ca cations by soil[a] and its different fractions in meq/100 g as a function of the pH of the equilibrium solution

Original soil		Trituration in paste state								Saturation with sodium cations							
pH	Ca adsorbed	pH	Ca adsorb 10.0-1.0μ dia. fract	pH	Ca adsorb. 1.0-0.2μ dia.fract	pH	Ca adsorb 0.2-0.5μ dia.fract.	pH	Ca adsorb by soil residue	pH	Ca adsorb 10.0-1.0μ dia.fract.	pH	Ca adsorb. 1.0-0.2μ dia.fract.	pH	Ca adsorb 0.2-0.5 μ dia.fract.	pH	Ca adsorb fract. <0.05 μ diam.
1.56	2.3	1.56	1.6	1.60	10.3	1.60	19.5	—	—	1.80	3.4	1,70	11.1	1.70	22.4	1.65	33,0
1.63	3.1	1.63	2.2	2.14	14.3	2.14	23.4	—	—	2.29	3.7	2.22	14.2	2.22	26,0	2.20	37.1
3.67	5.7	3.67	4.2	3.75	20.7	3.75	32.0	—	—	3.84	5.8	3.94	18.4	3.94	34.0	3.81	52.9
4.44	5.9	4.44	4.5	4.44	22.3	4.44	35.1	—	—	4.44	6.3	4.63	19.4	4.63	36.4	4.43	60,5
5.04	6.9	5.06	5.4	5.10	25.7	5.10	36.7	—	—	5.12	7.5	5.28	21.3	5.28	39.2	5.10	68.1
6.75	8.9	6.75	7.8	6.99	33.6	6.99	48.6	6.80	1.6	6.48	9.5	7.10	27.5	7.10	47.7	7.13	100.4

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[a] Soil from DACES.

Table 4

Adsorption of Ca cations by soil[a] and its different fractions in meq/100 g as a function of the pH of the equilibrium solution

Original soil		Trituration in paste state						Saturation of the soil sample with sodium cations									
								Without trituration				After trituration in the paste state					
pH	Ca adsorbed	pH	Ca adsorb 1.0-0.2μ dia.fract.	pH	Ca adsorb fract. 0.2μ dia.	pH	Ca adsorb by soil residue	pH	Ca adsorb 1.0-0.2 μ dia.fract.	pH	Ca adsorb fract. 0.2 μ dia.	pH	Ca adsorb 1.0-0.2 μ dia. fract	pH	Ca adsorb fract. 0.2 μ dia.	pH	Ca adsorb. by soil residue
1.70	4.1	1.88	14.3	1.88	27.7	—	—	—	—	1.67	25.3	2.26	14.3	1.85	21.0	—	—
3.53	5.6	—	—	3.04	35.6	—	—	—	—	3.49	34.7	3.67	13.9	3.12	28.3	—	—
4.22	5.7	3.92	18.2	3.92	37.8	—	—	—	—	4.18	36.1	4.20	13.9	3.94	32.3	—	—
4.74	5.5	—	—	4.55	38.4	—	—	—	—	4.70	35.9	4.69	13.9	4.55	28.3	—	—
5.51	6.1	—	—	5.29	39.5	—	—	—	—	5.38	36.9	5.41	15.2	5.33	28.3	—	—
6.40	7.2	6.46	25.5	6.46	44.8	6.47	0.74	6.54	22.8	6.49	44.9	6.50	22.2	6.41	35.3	6.49	0.6

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[a] Soil from DACES.

[b] Fractions separated after removal without preliminary trituration.

question, but also sesquioxides combined with silicic acid, as a result of the destruction of the crystal lattices of aluminum and iron silicates.

We studied the adsorption of calcium cations by fractions of different degrees of dispersion as dependent on the value of the pH of the equilibrium solution. The data for the DACES soil are given in Table 3, and for the Central Forest Preserve soil in Table 4.

We see from Table 3 that as the degree of dispersion increases the amount of adsorbed calcium rises. The quantity of cations adsorbed from a solution with a reaction close to neutral was, in meq/100 g of separates, 7.5-10.0 for the 10.0-1.0μ diameter fraction, 27.5-33.5 for the 1.0-0.2μ diameter fraction, 47.5-50.0 for the 0.2-0.05μ diameter fraction, and ~100.0 for the fraction <0.05μ in diameter.

If we compare the quantity of calcium cations adsorbed by fractions that are the same as regards degree of dispersion but differ with respect to the preparatory method used in removing the clay fractions, it is clear that they are almost the same for the 0.2-0.05μ diameter fraction. At all pH values the adsorption was higher for the 1.0-0.2μ diameter fraction isolated from soil which was ground in the paste state. This can probably be explained by the higher humus content in it than in a fraction of the same size separated from a soil sample saturated with sodium cations. The adsorption of calcium cations by the residual soil after removal of the particles <10.0μ in diameter at pH 6.8 is equal to 1.8 meq per 100 g (Table 3). This is probably governed by the 0.56% humus content.

It also follows from Table 4 that, when conditions are otherwise equal, the quantity of calcium ions adsorbed increases as the degree of dispersion of the fraction rises. For the same degree of dispersion, we find the same adsorption capacity, regardless of the method of preparing the soil before removal of the clay fraction. The lower adsorption capacity for the <0.2μ diameter fraction separated after trituration in the paste state from a soil sample saturated with sodium is explained by its lower humus content. If the clay fraction is removed from a soil after trituration in the paste state, the soil residue adsorbs at pH close to 7.0 only 0.70 meq of Ca per 100 g of residue. But if the clay fraction was removed from a sodium-saturated soil without trituration, and then after trituration, the soil residue adsorbed 0.59 meq of Ca per 100 g, i. e., a soil residue consisting of particles >1.0μ diameter has practically no exchange capacity if it does not contain appreciable amounts of humus.

Conclusions

1. Two methods of preparing samples of podzolic soils for separating clay fraction were investigated:

a) saturation of the soil with sodium cations; b) trituration of the soil paste. The clay fraction was divided into a series of fractions of different degrees of dispersion by centrifugation.

2. The adsorption capacity of the fractions increases continuously with increasing degree of dispersion. Mineral soil particles >1.0μ in diameter have practically no exchange capacity.

3. A change in the degree of dispersion of the particles is accompanied by a change in their chemical composition: the content of one group of constituents increases, that of a second group decreases, and that of a third group remains practically unchanged.

4. The chemical composition and adsorption properties of precolloidal and colloidal fractions is practically independent of the method of preparing the soil samples for separating clay fractions.

5. Precolloidal fractions (1.0-0.2μ in diameter) separated from two different horizons and from different podzolic soils have practically the same adsorption capacity.

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BIBLIOGRAPHY

1. SOKOLOV, V. I. 1949. Tubular supercentrifuges. Goskhimizdat.

2. JEFFRIES, C. D. 1941. A method of preparing soil for petrographic analysis. Soil Science. 52:451.

NATURE OF SOIL MOISTURE IN THE AMUR RIVER REGION[1]

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Agriculture in the Amur River region is concentrated in hill-plain, plain and low-lying districts of complex meso- and microrelief and is especially developed on the Zeya-Burein and Amur-Zeya plains. The former lies in the southeast (110-180 m above sea level) and the latter (a raised plain) in the northwest at 300-400 m. There is little running water on either plain but a profusion of flowless depressions and marshes along the watershed, the dimensions of which vary with atmospheric precipitation.

The hydrographic network is also poor. Most of the sources are gently sloping hummocked hollows (depressions) which merge to form rivers that flow in small eroded valleys. The water courses are narrow, shallow and meandering, and the rate of flow slight. The bottoms are poorly developed and overgrown with shrubs and sedge hummocks. These are lake and river plains partly composed of neogenic sands and clays (1, 4, 5).

The climate of Amur is monsoon (Fig. 1) with high pressure in the surface atmospheric layer in winter (767-769 mm) and low pressure (752-755 mm) in summer. Winter air temperature drops to -46°C — -50°C and the soil freezes, since the snow is thin, to a depth of more than 3 m; on clear spring days, when there is an atmospheric humidity deficit, there is considerable evaporation of soil moisture. Wind erosion affecting sown areas is a common occurrence (2).

The temperature is comparatively high during the summer monsoon (southerly and south-easterly winds) and precipitation is plentiful in late summer. Drought develops if annual precipitation falls below the long term mean. When there is prolonged torrential rain lasting into late summer or autumn, the soil becomes waterlogged.

Mean annual precipitation in the last 22 years (1936-1957) has been 482 mm in the Zeya-Burein low plain and 518 mm in the Amur-Zeya high plain, with an average for the warm months (April-September) of 442 mm or 91.7% in the low plain and 458 mm or 88.4% in the high plain and for the cold months (October-March) of 40 mm or 8.3% on the low plain and 60 mm or 11.6% on the high plain.

There is considerable variation for the annual totals during several years in the periods which precipitation occurs. Annual periodicity is determined from precipitation in the warm period (3).

The soil is thick, medium and thin dark meadow loams of fine clay and clays on the positive relief of the Zeya-Burein plain and meadow-bog and bog humus-gley and peat-humus-gley clays on the negative relief. There are podzolized-brown and meadow-brown-earth clays and clay loams and also thin meadow brown-earth marsh and meadow-marsh clays on the positive relief of the Amur-Zeya plain and meadow-bog, bog-humus-gley, peaty and peat-humus-gley clays on the negative relief.

The soil-forming parent materials are tertiary light-brown clay loams and clays bedded on tertiary medium-grained sands of varying color and stratification.

All the plain soils, except the podzolized-brown clay loams, have negative physical properties in relation to water. Despite the high total porosity of the layers beneath the plowed layer (48% and above), saturation moisture capacity is low (35% and less); field moisture capacity is more than 80% of total moisture capacity in these layers. Since the coefficient of water discharge of these soils is <0.1, they become waterlogged with slight precipitation. The wilting moisture is high (17%-19%) which means that the soils have a low total available

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[1] This work was carried out as part of the Amur combined expedition of the Council for the Study of Productive Resources (of the USSR Academy of Sciences).

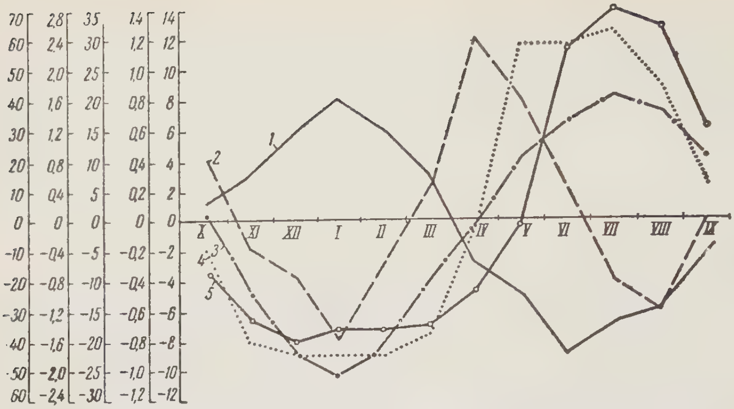

Fig. 1 - Annual variation of mean monthly climatic indices for the Amur region (mean values for the period 1913-1926).

1 - barometric pressure; 2 - wind velocity; 3 - air temperature; 4 - atmospheric moisture capacity deficit; 5 - precipitation.

moisture; the limits of the total moisture content in a 100 cm layer of such soils is only 40%-50% of the field moisture capacity. In dry years (<400 mm) there is no available moisture in the root layers. The water permeability in the subsoil is also low (<0.5 mm/min). The coefficient of horizontal filtration (CHF) is insignificant at 0.09-0.37 m/day in the first meter and 0.03-0.06 m/day in the second. The tertiary sands lying at various depths of the plains are quite permeable (21-46 mm/min).

Studies of the entry of atmospheric precipitation into the soil, the formation of soil moisture and ground water (waterlogging) and soil moisture consumption show that the soil profile dries out rapidly (Table 1) when precipitation is below normal. By the end of August the amount of moisture in the root layer is 3/4 to 1/2 the May total (maximum moisture capacity) and has reached the wilting moisture. The profile dries out to at least 3 m depth, the use being greatest in the 0-150 cm layer where it amounts to 125-166 mm or 23%-29% of the field capacity.

Table 1 shows that there is unequal moisture loss by layers as a result of evaporation and transpiration from abandoned area, perennial grasses, spring wheat and soya. Most moisture (41%-45% of the initial total) is used in the 0 to 50 cm layer, then 14%-20% in the 50 to 100 cm layer and 7%-11% in the 100 to 150 cm layer. Between 150 and 300 cm layer the consumption is insignificant at 3%-7%. The drying of the soil profile continues from spring to late autumn. The foregoing figures show that moisture consumption is in the main from the 0-50 cm root layer. When precipitation is considerable (an average of 3.5 mm a day in 1954) or above the average annual level (1955), moisture accumulates in the soil. A total of 141 mm of precipitation at an average daily rate of 3.5 mm wets the soil profile to a depth of 50-60 cm. Total moisture content is increased in this case by 65-36 mm and aeration reaches the critical stage at which plants may suffer from the lack of oxygen and reducing processes. Following a 309 mm of precipitation the soil profile is wetted to a depth of 150 cm. The total moisture content in a 300 cm layer was increased by 192 mm. Additional 350 mm of precipitation increased the total moisture content by 62-92 mm.[2]

Saturation of the drier upper section of the soil profile by precipitation is followed by gradual saturation of the less dried lower layers in which waterlogging occurs mainly in the 50-150 cm layer because at a lower level the parent material has a zero coefficient of water discharge.

A study of the moisture of the 8-12 m layer shows that variations in the total moisture content as a result of dry and wet years may extend to considerable depths. Table 2 shows that in 1954 the soil-profile dried out to a depth of 4.0-4.5 m, below which the total moisture contents remained unaffected for a considerable period at field moisture capacity (the level of which varied in relation to the texture of the parent material.

Table 2 shows that precipitation (660 mm) in 1954-55 penetrated to a depth of 450 cm and that 152 mm entered the soil and the remaining 508 mm were lost through evaporation and surface flow. If we accept a total moisture loss of

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[2] The skies were clear at this time and evaporation was intensive.

Table 1

Total soil moisture, mm depth of the water

Depth, cm	Saturation field capacity	Wilting moisture	1953	1954			1955		Moisture consump.	Moisture intake					Total mois. used
			Oct. 7	May 21	Aug. 21	Oct. 6	July 10	Oct. 7	Fr. May 21 to Aug. 21 1954	Fr. Aug. 21 to Oct. 6, 1954	Oct. 6, 1954 to July 10, 1955	July 10, 1955 to Oct. 7, 1955	Aug. 21, 1954 to Oct. 7, 1955	Oct. 7, 1953 to Oct. 6, 1954
Profile 3 Top of slope, $\underline{i} = 0.005$. Abandoned thick dark meadow clay															
0—50	233	103	189	182	106	171	188	193	—76	+65	+17	+5	+87	—18
50—100	191	136	207	206	165	169	204	202	—41	+4	+35	—2	+37	—38
100—150	198	127	212	215	191	176	206	204	—24	—15	+30	—2	+13	—36
150—200	—	—	218	220	217	189	214	225	—3	—28	+25	+11	+8	—29
200—250	—	—	204	205	191	195	214	241	—14	+4	+19	+27	+50	—9
250—300	—	—	215	213	211	210	213	236	—2	—1	+3	+23	+25	—5
0—300	—	—	1245	1241	1081	1110	1239	1301	—160	+29	+129	+62	+220	—135— —322=457
Profile 3 Final third of slope, $\underline{i} = 0.007$. Abandoned thick dark meadow clay															
0—50	215	98	185	187	93	160	231	209	—94	+67	+71	—22	+116	—35
50—100	219	121	201	213	161	159	224	226	—52	—2	+64	+3	+65	—42
100—150	214	125	193	193	173	156	204	194	—20	—17	+48	—10	+21	—37
150—200	—	—	200	204	189	185	203	207	—15	—4	+18	+4	+18	—20
200—250	—	—	211	220	197	208	201	220	—23	+11	—7	+19	+23	—3
250—300	—	—	215	215	205	212	210	220	—10	+7	—2	+10	+15	—3
0—300	—	—	1210	1232	1018	1080	1272	1276	—214	+62	+192	+4	+258	—130— —322=452
Profile 6 Final third of slope, $\underline{i} = 0.022$. Siberian wild rye. Medium dark meadow soil															
0—50	247	112	202	198	116	202	209	215	—82	+86	+7	+6	+90	0
50—100	195	126	194	193	172	169	190	208	—21	—3	+21	+18	+36	—25
100—150	198	137	208	202	180	180	180	201	—22	0,0	0	+21	+21	—28
150—200	—	—	191	188	198	190	184	201	+5	—4	—6	+17	+17	—1
200—250	—	—	206	191	188	181	187	214	—3	—7	+6	+27	+26	—25
250—300	—	—	219	188	190	194	208	206	+2	+4	+9	+3	+16	—35
0—300		—	1220	1160	1039	1116	1153	1245	—121	+77	+37	+92	+206	—104— —322=426
Precipitation mm	—	—	—	—	—	—	—	—	129	141	309	350	800	322

Table 2

Total of moisture content in the soil Profile No. 2 mm depth of water

Depth, cm	Aug. 20, 1953	1954		1955	Moisture consumption		Moisture intake fr. Oct. 6, 1954 thru Oct. 7, 1955
		May 19	Oct. 7	Oct. 6	Fr. Aug. 20, 1953 to May 19, 1954	Fr. May 19, 1954 to Oct. 6, 1954	
0—100	389	335	329	370	—54	—6	+41
100—200	354	355	346	344	+1	—9	—2
200—300	261	263	234	272	+2	—29	+38
300—400	90	83	77	130	—7	—6	+53
400—450	32	32	34	56	0	+2	+22
450—500	32	31	37	37	—1	+6	0
500—600	79	79	65	60	0	—14	—5
600—700	102	93	103	108	—4	+5	+5
700—800	—	293	—	292	—	—	—
0—450	1126	1068	1020	1162	—58	—48	+152
450—700	213	208	205	205	—5	—3	0

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[a] During this period of time, when intensive evaporation of moisture from the earth was taking place, the days were clear.

377 mm in this sector were due only to evaporation, then surface flow would be 508-377 = 131 mm. In sectors with a thick stratum of clay, 200-250 mm of moisture was incorporated in a 3 m layer on October 7, 1955 (Table 1). Precipitation in the period August 21, 1954-October 7, 1955 was 800 mm, of which evaporation and surface flow accounted for 550-600 mm. Total evaporation was 430-450 mm and on surface flow 120-150 mm. It follows that 120-150 mm, or 17%-20% of total annual precipitation, is uncontrolled surface flow in wet years in the Amur region.

The waters of the uncontrolled surface flow are haphazardly distributed throughout the greatly undulating plains where they increase the number and dimensions of the bogs and lakes that make the pre-Ural lands marshy.

Our investigations show that the subsurface water level is raised nearly to the surface after 525 mm of precipitation at an average of 5.2 mm a day. When the average rain intensity is 1 mm a day the subsurface water level begins to decline. It has been shown over a number of years that the subsurface water level falls to below 1.5 m at the end of October and that excessively wet soils do not freeze to such depth as soils with a dry profile (Fig. 2). When summer precipitation is slight the seasonal freezing of the ground (to 2.8-3.0 m) thaws completely by mid August; when summer (warm) precipitation is plentiful the thaw is complete by the end of July. At the end of August patches of frozen ground only remain beneath established grass on northerly slopes. There is permafrost beneath sphagnum and sedge hummocks on all north-facing slopes and bottoms on the Amur-Zeya plain. The ground-water table lies at 6-8 m low down on the slopes and at 25-40 m or lower on the ridges: Both ground water and subsurface water are slightly mineralized at the silicate-carbonate stage and the ground water includes up to 36 mg/l of silicate.

The chronoisopleths of the extent to which the soil pores are filled with water (Fig. 3) and the formation of the first ground-water level below the bed of tertiary sands that underly the parent materials, show that atmospheric precipitation is the main source of soil moisture on the low Zeya-Burein and high Amur-Zeya plains.

A study of the soil moisture profile and of the underlying parent materials showed that the lower part of the profiles is wetted to between field capacity and maximum moisture capacity independently of the total annual precipitation. Ground water and gravitational soil moisture (subsurface water) are formed in this section of the profile during the monsoon rains; in the upper part of the profile moisture varies by year and season from field moisture capacity to wilting moisture. The wetting of this part of the profile is directly related to the intensity and total of annual precipitation. In dry years (less precipitation than the long term average) this part of the profile reaches the wilting moisture, while in wet years it is wetted to field moisture content and greater.

Meadow soils form on the Zeya-Burein plain and meadow-marsh and brown earths-marsh clays on the Amur-Zeya plain; the soils of the

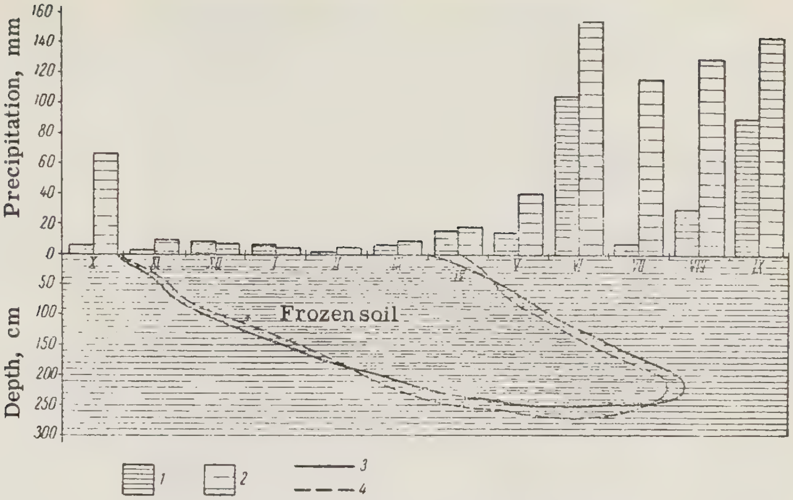

Fig. 2 - Mean monthly precipitation, freezing and thawing of the soil in 1953-1955 (figures of the Amur Region plant breeding station).

Precipitation, mm: 1 - 1953; 2 - 1954-1955. Freezing and thawing of soil; 3 - 1953-1954; 4 - 1954-1955.

podzolized profile are coarse-textured and subject to leaching in the summer and autumn; bog soils (meadow-bog, humus-gley, peaty and peat-humus-gley) form in medium or small closed depressions and gently sloping hummocked hollows owing to atmospheric precipitation and surface flow. The meadow and bog soils on the first terraces and in the valley bottoms are wetted by ground water, atmospheric water and additional surface water. In bog soil formation the ground water and gravitational soil moisture (subsurface water) comes to the surface after the monsoon; in meadow soils it lies near the surface, while in the podzolized profile it is either absent or does not ascend above the lower part of the profile.

The ground water and gravitational water of the Amur region does not have a permanent water table but is seasonal. It should be noted that the ground water and gravitational water of the Amur region develops in two stages; in summer it forms during the monsoon owing to the low water discharge of the parent materials, while in spring and early summer it is formed owing to the removal from soil containing ice layers from the saturated part of the profile, in which case the unthawed portion of the seasonal freezing is impervious to water. The second stage does not develop if the preceding year was dry.

Conclusions

1. When annual precipitation is below normal the soil dries out to a considerable depth. The upper rooting layer of the soil dries out the most and the available moisture is almost used up in August.

2. The amount and intensity of precipitation may vary in the same year in the low Zeya-Burein and high Amur-Zeya plains, with excess moisture in the one and drought in the other, and also the reverse.

3. The soil-profile is wetted to a depth of 3 m by 700-750 mm of precipitation. Under these conditions ground water and gravitational water are formed at 50-150 cm from the surface. Subsurface water reaches the surface here when precipitation is of average intensity (5.2 mm a day).

4. Rough calculations show that 17%-20% of total annual precipitation is in uncontrolled surface flow in wet years. Much of this surface flow is local (lake formation).

5. The freezing of the soil-profile during the winter extends to >3 m. Thawing is completed by the end of July or the first half of August. Permafrost occurs in slopes and bottoms on the Amur-Zeya plain. Frost fissures are most developed in boggy and excessively wet soils where they reach a depth of 1.6 m and are usually filled with clear double cleaved ice.

6. Bog, meadow and podzolized soils are formed in the Amur region.

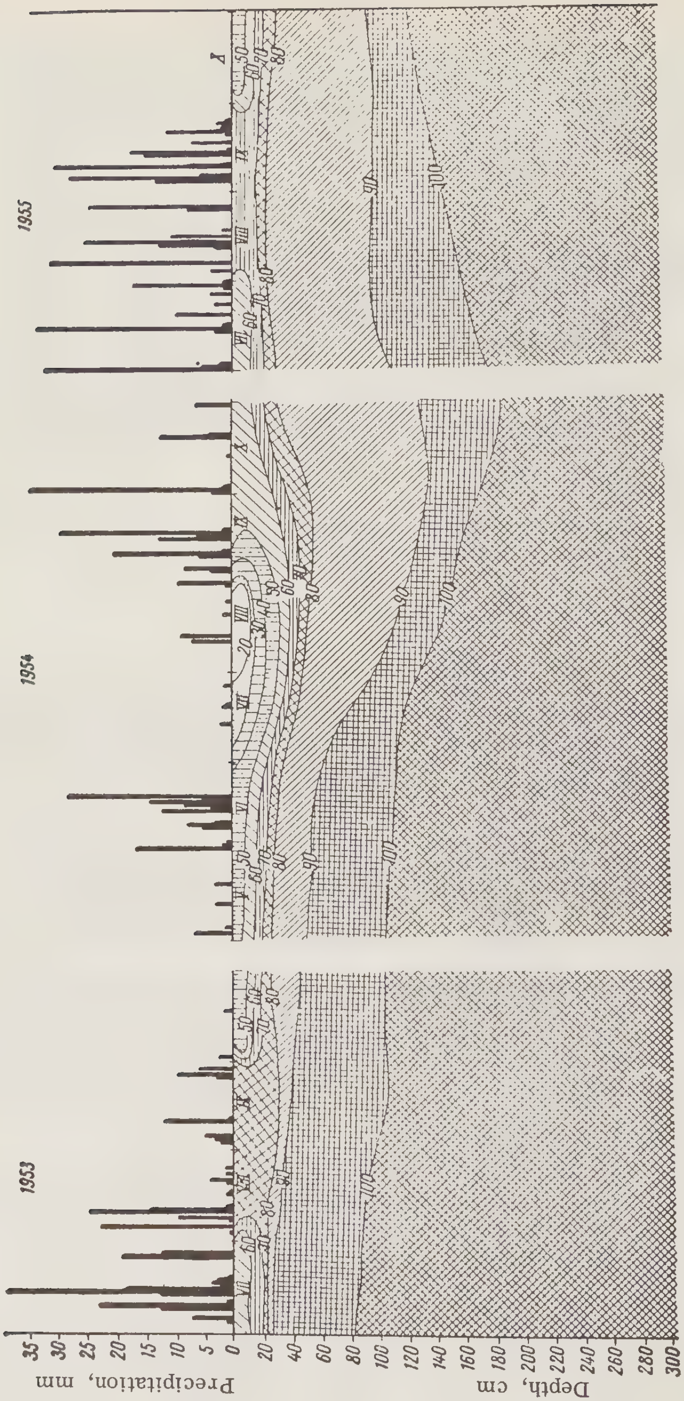

Fig. 3 - Chronoisopleths of the extent to which the pores of the soil are filled with water (as percentages of total porosity). Thick dark meadow clay soil, Tambovka, Amur Region.

7. Ground water and gravitational water (surface water) reaches the surface during the monsoon in bog soils, comes close to the surface in meadow soils and is absent from or of brief duration in the lower part of the profile in podzolized soils.

8. There is no permanent ground-water table and gravitational water, which are biphasic in the Amur region: in summer they form during the monsoon rains owing to the low water discharge of the parent material, and in spring and early summer owing to winter freezing from the excessively wet part of the

soil profile (in which case the unthawed portion of the winter freezing is impervious to water).

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BIBLIOGRAPHY

1. BOGOLYUBSKIY, I. 1876. A sketch of the Amur District, the Primor'ye and Sakhalin.

2. NOVAK, A. G. 1953. The fundamentals of Agriculture in the Far East. Khabarovsk.

3. PUSTOVOYTOV, N. D. 1957. Physical properties and the air-water regime of the soils of the southwest sector of the Zeya-Burein plain. Pochvovedeniye No. 6.

4. CHEMEKOV, YU. F. 1956. An attempt to divide the south of the Soviet Far East into geomorphological regions. Materials on Quaternary geology and geomorphology. No. 1. VSEGEI.

5. CHEMEKOV, YU. F. 1956. Geomorphology of the Zeya-Burein-Amur depression. In: Materials on Quaternary geology and geomorphology). No. 1. VSEGEI.

FOREST LITTER AND ITS ROLE IN FORMATION OF FOREST SOIL HUMUS IN THE THE SOUTHERN FOREST-STEPPE

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There is no general consensus of opinion among investigators on the significance of the decomposition products of plant stems and leaves to the formation and accumulation of soil humus. Kostychev (6) concluded that organic matter accumulates in chernozems exclusively from the decomposition of dead roots. Vilenskiy (1) indicates that this hypothesis is confirmed for soils in treeless districts by studies of the root systems of grasses in the sod-podzolic and chernozem zones. A similar view is upheld by Tyurin (21) who thinks that litter is subsidiary to roots.

Other investigators (7, 8, 15, 24, etc.) have ascribed the formation of humus to the soluble organic compounds leached from plant residues above the soil surface and think that dead roots are a subsidiary source of the organic matter involved in the formation and accumulation of humus. The eminent forestry expert and geographer Morozov (11) treats forest litter as one of the most important components in soil formation and the source of forest soil humus.

M. M. Kononova (5) notes that since tree roots are coarser and longer lived than grass roots they form a small amount of humus, the chief source of which in forest soils (without grass) is forest litter, from which organic matter enters the soil layers as leached solutions. Zonn (4) thinks that forest litter accumulates organic, nitrogenous and ash substances and regulates the consumption of nutrients by protecting them from excessive leaching. Rode (14) stresses that organic remains from dead animals or their organs on the surface or in the upper layers of the soil are the main source of soil humus.

Stepanov (19) found that forest litter and its decomposition products and mineralization played an important part in the accumulation of humus and influenced its qualitative composition on which soil fertility and, consequently, the productivity of forest plantations depend.

Orlov (12) demonstrated that the dead absorbing roots of forest vegetation are an insignificant part. Thus, in a two meter layer of forest-steppe in the Orlov region (Moscow Forestry Board) planted with 50 year spruce the annual total of root litter participating in humus formation is approximately 0.6 metric tons/ha, or about one-fifth of the dry mass of the annual litter.

We wish to point out, without going into further detail, that a detailed study of the formation, properties, composition and decomposition of forest litter is essential to an understanding of soil formation in forest soils.

The following experiment was conducted in the Tellerman Experimental Plantation of the USSR Academy of Sciences. Four 10 x 10 m plots were laid out in 220 year oak-ash forest with gout weed (quadrat 37) on dark-gray soils and in 60-70 year oak on residual podzolized-solodized solonetz (quadrat 29).[1] Two of these plots were cleared of litter and grass and the other two were left untouched. After 40 months (September 20, 1954) soil samples were taken to examine the group and fractional composition of the humus and to determine nitrogen and pH.[2] Five to six sets of samples were taken by genetic horizon down to a depth of 40-60 cm and the samples were then carefully mixed to produce an average sample for each depth.

There had been an uneven accumulation of litter beneath the oak canopy. Four times as much litter had accumulated in the solonetz oak stand (80 metric tons/ha dry mass) than in the oak-ash stand (17). This was due both to the qualitative composition of the litter and to the nature and decomposition rate of the plant residues. The presence and removal of litter was reflected both in the accumulation of biogenic elements in the soils and in the variation in actual acidity (Table 1).

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[1] Zonn's paper (2) gives a more detailed description of the soils.

[2] The group and fractional composition of the humus was determined according to the precedure and outline given by Tyurin (22); nitrogen by Kjeldahl's micromethod; pH by electrometry with a glass electrode.

was lowest in both oak stands on the plots cleared of litter. Sharper contrasts in the content of these components were revealed in the soil of various plots of the ash-oak stand, both in the separate horizons and for the 40 cm layer as a whole (Table 2).

Table 1

Variation of pH and total nitrogen and humus content in soils

Soil and forest type	Plot	Horizon and depth, cm	pH (water)	As a % of dry soil		Ratio of (humus) C to (total) N
				N	humus	
Dark-gray forest Ash-gout weed oak wood (quadrat 37)	With natural cover	A_1 3-8	6.67	0.783	12.03	8.9
		A_1 8—13	6.68	0.692	9.83	8.2
		A_1'' 13—23	6.48	0.359	4.24	6.8
		A_1''' 23—33	6.01	0.282	4.07	8.4
		A_1''' 33—43	5.55	0.209	2.33	6.4
	Without cover	A_1' 0—5	6.40	0.685	9.90	8.3
		A_1' 5—10	6.06	0.417	5.41	7.5
		A_1'' 10--20	5.94	0.246	3.67	8.6
		A_1''' 20—30	5.77	0.240	2.72	6.6
		A_1''' 30-40	5.74	0.149	1.95	7.6
Residual podzolized-solodized solonets Solonetz oak stand (quadrat 29)	With natural cover	A_1 6—8	4.78	0.931	16.65	10.4
		A_2 8—9	4.95	0.265	4,28	9.4
		A_2B_1 9—23	2.93	0,275	4.22	8.9
		B_2 23—62	4.95	0,227	3.17	8.2
	Without cover	A_1 0—2	5.14	0,858	16.34	11.0
		A_2 2—3	5.11	0,225	4.19	10.8
		A_2B_1 3—17	4.94	0,274	3.83	8,2
		B_2 17—56	5.40	0.185	2.57	8,1

Note: The soil samples were taken from the same depth in the plots in each forest. Thus the depth 3-8 cm in the ash-gout weed oak stand plot with litter corresponds to 0-5 cm on the plot without litter, and so on.

As has been mentioned, the litter differed in composition. In the solonetz wood it consisted exclusively of oak litter in various stages of decay (99.3%), whereas 73% of the litter in the forest with gout weed consisted of maple, ash, basswood, hazelnut and elm species (9). Actual acidity varied in relation to growing conditions and the qualitative composition of the litter. The pH of a water suspension was 5.93 for the litter of the ash gout weed-oak forest and 5.45 for the solonetz oak forest (18). Removal of the litter with the lower pH value slightly reduced the acidity of the residual podzolized-solodized solonetz (by a pH value of 0.2-0.4). Acidity was most reduced in the deeper soil horizons (B_2), which are less affected by the organo-mineral compounds leached from the litter.

The nitrogen and humus content of the soil

The humus content was lowered by 25.8% and the nitrogen by 20.6% in the soil under the ash-gout weed-oak stand without litter. There was less difference in the accumulation of substances containing carbon and nitrogen in the podzolized-solodized solonetz, owing, no doubt, to the reduced intake of organo-mineral compounds leached from the decomposing plant residues in the deepest layers of the soil and to their weaker fixation by soil colloids (3, 16).

Influence of the Mobile Decomposition Products of Forest Litters on Variation in the Group Composition of the Humus. The group composition of the humus underwent considerable change in the plots without natural cover in both stands. The ratio of humic acids to fulvic acids is almost invariably greater than unity and somewhat higher on the plots cleared

Table 2

Relative nitrogen and humus content in a 40 cm soil layer

Oak stand	Plot	Nitrogen		Humus	
		% of dry matter	"b" as a % of "a"	% of dry matter	"b" as a % of "a"
Ash-gout weed	With litter "a"	0.397	—	5.39	—
	Without litter "b"	0.315	79.4	4.00	74.2
Solonetz	With litter "a"	0.280	—	4.24	—
	Without litter "b"	0.250	89.2	3.75	88.4

of litter (Table 3).

The removal of the litter also had a different effect on the ratio of these two groups, the variations being greatest in the podzolized-solodized solonetz, where the ratio varied in the separate horizons of the cleared plots between 1.16-2.11. The highest value was recorded in the A_2 horizon, where the dark-brown humic acids were accumulated in the main (fraction I) and there was only a slight increase in the content of fulvic acids. On the plot with litter the same horizon had an increased content of humic and fulvic acids, which increased their ratio (1.84) in the A_2B_1 horizon. The content of humic acids and especially fulvic acids is reduced here by comparison with the A_2 horizon owing to the more intensive leaching of the latter in the B_2 horizon. The amount of fulvic acids in the B horizon exceeds that of the humic acids by 1-1/2 times and this lowers their ratio to 0.72. No such phenomenon was observed on plots without litter.

The ratio of the humic acids to the nonhydrolyzed residue in the dark-grey forest soil beneath the plot covered with litter rose sharply at a depth of 13 cm. This ratio also increased with depth on the plot without litter.

The ratio of humic acid to nonhydrolyzed residue was not affected by the absence of litter on the surface of the podzolized-solodized solonetz beneath the forest canopy. These ratios are low and close together in both the accumulative and illuvial horizons of the two plots, owing to the increased nonhydrolyzed residue in these soils and a somewhat diminished accumulation of humic acids ratios of the main humic groups in the 40 cm layer a somewhat different distribution from that in the separate horizons is revealed (Table 4).

Removal of the litter beneath the forest canopy is shown to have led in 40 months to a considerable reduction in the content of humic compounds of all the groups. The order of their relative decrease in the soil beneath the ash-gout weed-oak stand differs from that in the podzolized-solodized solonetz.

The relative decline of the humic substances in the dark-grey forest soil on the plot without litter is in the following order: humic acids — nonhydrolyzed residue — compounds that are hydrolyzed in 0.5-1.0 n N_2SO_4 — substances that are soluble when decalcified in sodium sulfate. In the solodized solonetz soils the relative content of substances extracted by alcohol-benzene (wax-resins) decreased by 22.2% and moved down to the penultimate position, whereas the fulvic acids moved two groups to the left.

Only the humic acids, as the biochemically most stable compounds, and the easily mobile humus substances which are soluble when the soils are decalcified, remained in their former places, although the ratios between these groups of organic substance are extremely different, being 19.2 for dark-gray forest soil and only slightly more than half at 9.7 for the podzolized-solodized solonetz.

Ones attention is drawn to another phenomenon associated with the mobility of the various groups of humic substance. The ratio of humic acids to soil humins remains constant or varies only slightly. This ratio is 1.44 in the dark-gray forest soil with litter, 1.50 on the plot without litter and 0.59 on both plots of podzolized-solodized solonetz. Thus the accumulation, decomposition and mineralization of humic acids and soil humins here are due to decomposition and to the synthesis of macromolecular substances in related proportions. The latest research (6, 20, 23, etc.) shows that the nonhydrolyzed residue (humins) consists of humic acids that are, in general, quite similar in composition to the humic acids extracted from decalcified soils but are more closely bonded with the mineral component of the soil.

Table 3

Composition by group and fraction of humic substances in soils of the Tellerman Experimental Forest

Plots	Depth, in cm	Initial C content	to dry soil / of the group or fraction to the initial C content of the soil				
			compounds of C in the form				
			of substances extracted by alcohol-benzene	of substances soluble in 1.0 n Na_2SO_4	of humic acids		
					fractions		
					I	II	III
Ash-gout weed with forest litter	3—8	6.98 100.0	0.27 3.9	0.30 4.3	0.43 6.3	1.03 14.7	0.56 7.9
	8—13	5.70 100.0	0.19 3.3	0.26 4.6	0.47 8.2	0.93 16.3	0.48 8.5
	13—23	2.46 100.0	0.08 3.3	0.08 3.3	0.22 9.0	0.67 27.2	0.22 8.9
	23—33	2.36 100.0	0.07 3.0	0.06 2.5	0.06 2.5	0.82 34.7	0.19 8.1
	33—43	1.35 100.0	0.05 3.7	0.02 1.5	0.07 5.2	0.51 37.8	0.09 6.6
The same without litter	0—5	5.74 100.0	0.20 3.5	0.14 2.4	0.47 8.2	1.03 18.0	0.53 9.2
	5—10	3.14 100.0	0.11 3.5	0.07 2.2	0.30 9.5	0.69 22.0	0.26 8.3
	10—20	2.13 100.0	0.06 2.8	0.04 1.9	0.11 5.2	0.64 30.0	0.21 9.9
	20—30	1.58 100.0	0.05 3.2	0.05 3.2	0.05 3.2	0.52 32.9	0.13 8.2
	30—40	1.13 100.0	0.05 4.4	0.02 1.8	0.05 4.4	0.39 34.5	0.10 8.9
Solonetz with forest litter	6—8	9.66 100.0	0.42 4.3	0.14 1.4	2.13 22.0	0.21 2.2	0.18 1.9
	8—9	2.48 100.0	0.13 5.2	0.06 2.4	0.72 29.0	0.08 3.2	0.07 2.8
	9—23	2.45 100.0	0.15 6.1	0.07 2.9	0.56 22.9	0.16 6.5	0.09 3.7
	23—62	1.84 100.0	0.18 9.8	0.08 4.3	0.18 9.8	0.14 7.6	0.04 2.2
The same without litter	0—2	9.48 100.0	0.42 4.4	0.08 0.8	2.09 22.1	0.24 2.5	0.18 1.9
	2—3	2.43 100.0	0.11 4.5	0.04 1.7	0.80 32.9	0 0	0.09 3.7
	3—17	2.24 100.0	0.15 6.7	0.05 2.2	0.56 25.0	0.04 1.8	0.06 2.7
	17—56	1.50 100.0	0.12 8.0	0.06 4.0	0.12 8.0	0.20 13.3	0.04 2.7

Table 3 Continuation

to dry soil / of the group or fraction to the initial C content of the soil								Ratio of C of the humic acids to	
compounds of C in the form									
total	of fulvic acids				total	of substances hydrolyzed in 0.5-1.0 n H_2SO_4	of the nonhydrolyzed residue	C of the fulvic acids	C of the nonhydrolyzed residue
	fractions								
	Ia	I	II	III					
2.02	0	0.40	0.61	0.62	1.63	0.50	2.17	1.23	**0.90**
28.9	0	5.7	8.8	8.9	23.4	8.5	31.0		
1.88	0	0.43	0.50	0.55	1.48	0.43	1.46	1.27	**1.28**
33.0	0	7.5	8.8	9.7	26.0	7.5	25.6		
1.11	0	0.17	0.11	0.20	0.48	0.15	0.56	2.31	**1.98**
45.1	0	6.9	4.5	8.1	19.5	6.1	22.7		
1.07	0	0.09	0.29	0.13	0.51	0.11	0.54	2.10	**2.00**
45.3	0	3.8	12.3	5.5	21.6	4.7	22.9		
0.67	0	0.04	0.15	0.03	0.22	0.06	0.33	3.04	**2.03**
49.5	0	3.0	11.7	2.2	16.3	4.4	24.5		
2.03	0	0.47	0.37	0.40	1.24	0.40	1.73	1.63	**1.17**
35.4	0	8.2	6.4	7.0	21.6	7.0	30.1		
1.25	0	0.28	0.20	0.27	0.75	0.13	0.83	1.66	**1.50**
39.8	0	8.9	6.4	8.6	23.9	4.1	26.5		
0.96	0	0.12	0.15	0.12	0.39	0.09	0.59	2.46	**1.62**
45.1	0	5.6	7.1	5.6	18.3	4.2	27.7		
0.70	0	0.05	0.17	0.11	0.33	0.07	0.38	2.12	**1.84**
44.3	0	3.1	10.8	7.0	20.1	4.4	24.0		
0.54	0	0.04	0.10	0.04	0.18	0.04	0.30	3.00	**1.80**
47.8	0	3.5	8.8	3.5	15.9	3.5	26.6		
2.52	0.21	1.02	0.12	0.20	1.55	0.37	4.66	1.62	**0.54**
26.1	2.2	10.5	1.2	2.1	16.0	3.9	48.3		
0.87	0.10	0.17	0.20	0.08	0.55	0.07	0.80	1.58	**1.09**
35.0	4.0	6.9	8.1	3.2	22.2	2.8	32.4		
0.81	0.15	0.15	0.11	0.03	0.44	0.09	0.89	1.84	**0.91**
33.1	6.1	6.1	4.5	1.2	17.9	3.7	36.3		
0.36	0.16	0.08	0.24	0.02	0.50	0.80	0.64	0.72	**0.56**
19.6	8.7	4.4	13.0	1.1	27.2	4.3	34.8		
2.51	0.35	0.70	0.30	0.16	1.51	0.37	4.59	1.66	**0.55**
26.5	3.7	7.4	3.1	1.7	15.9	3.9	48.5		
0.89	0.16	0.13	0.06	0.07	0.42	0.10	0.87	2.11	**1.02**
36.6	6.6	5.4	2.5	2.8	17.3	4.1	35.8		
0.66	0.21	0.07	0.20	0.06	0.54	0.07	0.77	1.22	**0.86**
29.5	9.4	3.1	8.9	2.7	24.1	3.1	34.4		
0.36	0.14	0.04	0.11	0.02	0.31	0.07	0.58	1.16	**0.62**
24.0	9.3	2.7	7.3	1.4	20.7	4.7	38.6		

Table 4

Group composition of humus in 40 cm layer of the soils as a percentage of the dry matter

Oak stand	Plot	Total C	Substances extracted by alcohol-benzene	Compounds soluble in 1.0 n Na_2SO_4	Humic acids	Fulvic acids	Compounds hydrolyzed in 0.5-1.0 n H_2SO_4	Nonhydrolyzed residue	C of humic acids / C of fulvic acids
Gout weed	With litter "a"	3.13	0.11	0.11	1.21	0.70	0.16	0.84	1.73
	Without litter "b"	2.32	0.08	0.05	0.93	0.47	0.12	0.64	2.05
	"b" as a % of "a"	74.2	72.7	45.4	79.3	67.1	75.0	76.0	—
Solonetz	With litter "a"	2.45	0.18	0.08	0.64	0.52	0.10	0.93	1.23
	Without litter "b"	2.17	0.14	0.06	0.59	0.45	0.08	0.85	1.29
	"b" as a % of "a"	88.6	77.8	75.0	92.2	86.5	80.0	91.4	—

The following brief conclusion can be drawn from the foregoing on the influence which soluble organic matter leached from forest litter has no quantitative variations in the humus of dark-gray forest soils and podzolized-solodized solonetz soils. The content of humic matter is considerably reduced in soils on plots cleared of litter and varies with depth within the range 16%-45% in dark-gray forest soils and 1.9-18.5% in podzolized-solodized solonetz soils. This is undoubtedly connected with unfavorable conditions for the decomposition and mineralization of the humus as a result of a general retardation of biochemical processes from poorly developed microflora (13).

The lowering of the humic matter content in the plots with removed litter in both oak plots, as compared with plots with litter affects all humus groups and reaches an average of 25.8% for the upper 40 cm of the soil layer in the gout weed oak stand and 11.4% in the solonetz.

Nonspecific organic substances, i. e., substances that are soluble when the soil is decalcified, wax-resins and, to some extent, the fulvic acid group of dark-gray forest soil, are subject to considerably larger variation. When the litter is removed, the conversion of humic matter acquires greater impetus than on the plots with untouched cover, owing to better aeration and the greater heating capacity of the surface layers of the soils.

Alteration of the Group Composition of Nitrogenous Substances in the Soils Studied. The distribution of nitrogen in the groups of the humus complex (Table 5) is in a somewhat different order than that of humus carbon. Humic acids exceed fulvic acids in the make up of humic substance in the soils (Table 3) and also exceed the nonhydrolyzed residues in the dark-gray soils, with the exception of the A_1' subhorizon (3-8 cm). In the podzolized-solodized solonetz soils the content of nonhydrolyzed compounds exceeds that of the humic acids, except in the podzolized A_2 horizon of the plot without litter, where the ratio between the first and third groups is 1.00. Here the distribution of nitrogenous matter is similar to the distribution curve for the soil humus groups. As a whole, compounds of nitrogen intimately bonded with nonhydrolyzed residues or more mobile forms that are extracted with the fulvic acids predominate in the soils from solonetz oak stand, the content of the latter group being greatest in soils with litter. A similar picture is to be seen in the upper 10 cm of the plot with litter and in the upper 5 cm of the plot without litter in the ash-gout weed-oak stand. In the latter case, extremely close ratios varying between 0.62 and 0.93 are obtained for the humic and fulvic acids and for the humic acids and the nonhydrolyzed residues.

Table 5

The effect of substances leached from the decomposing litters on alteration in the group composition of nitrogen in the soils $\left(\% \frac{\text{of N to dry soil}}{\text{of N to its total content in the soil}}\right)$.

Oak stand	Plot	Depth, cm	Initial content of N	Nitrogen in the group					Ratio of N of the humic acids to N	
				of compounds soluble on decalcification	of humic acids	of fulvic acids	of substances soluble in 0.5-1.0 n H_2SO_4	of the nonhydrolyzed residue	of the fulvic acids	of the nonhydrolyzed residue
Ash-gout weed on dark-gray forest soils	With litter	3—8	0.783 100.0	0.046 5.9	0.168 21.5	0.231 29.5	0.104 13.2	0.234 29.9	0.73	0.71
		8—13	0.692 100.0	0.041 5.9	0.172 24.9	0.200 28.9	0.093 13.4	0.186 26.9	0.86	0.93
		13—23	0.359 100.0	0.029 8.1	0.097 27.0	0.069 19.2	0,070 19.5	0.094 26.2	1.40	1.03
		23—33	0.282 100.0	0.031 11.0	0.098 34.8	0.035 12.4	0.053 18.8	0.065 23.0	2.80	1.51
		33—43	0.209 100.0	0.037 17.7	0.065 31.1	0.019 9.1	0.027 12.9	0.061 29.2	3,42	1.07
	Without litter	0—5	0.685 100.0	0.058 8.5	0.137 20.0	0.222 32.4	0.068 19.9	0.200 29.2	0.62	0.69
		5—10	0.417 100.0	0.020 4.8	0.142 34.0	0.118 28.3	0.047 11.3	0.090 21.6	1.20	1.57
		10—20	0.246 100.0	0.008 3.3	0.065 26.4	0.043 17.5	0.072 29.2	0.058 23,6	1,51	1.12
		20—30	0.240 100.0	0,027 11.2	0,070 29.2	0,021 8,8	0,062 25.8	0.060 25.0	3.33	1.16
		30-40	0.149 100.0	0.019 12.8	0.030 20.1	0,018 12.1	0.028 18.8	0.054 36.2	1.66	0.55
Solonetz on residual podzolized solonetz	With litter	6—8	0.931 100.0	0.061 6.6	0.223 24.0	0,270 30.0	0.049 5.2	0.328 35.2	0,80	0.68
		8—9	0.265 100.0	0.033 12.5	0.068 23.8	0,069 26.0	0.021 7.9	0.079 29.8	0,91	0.80
		9—23	0.275 100.0	0.038 13.8	0,064 23.3	0.070 25.5	0.034 12.3	0.069 25.1	0.97	0,92
		23—63	0.227 100.0	0.037 16.3	0.031 17.2	0,057 25.1	0,039 17.2	0.055 24.2	0.68	0.71
	Without litter	0—2	0,858 100.0	0.019 2.2	0,177 20.6	0,223 26.0	0.038 4.4	0.401 46.8	0.79	0.44
		2—3	0.225 100.0	0.019 8.4	0,069 30.6	0.043 19.1	0.036 16.0	0.058 25.8	1,50	1,19
		3—17	0.274 100.0	0.014 5.1	0,074 27.0	0,070 25.6	0.036 13.1	0.080 29.2	1.06	0.92
		17—56	0.185 100.0	0.050 27.0	0.027 14.6	0,041 22.2	0.021 11.3	0.046 24.9	0.66	0,59

Note: a) The reagents (Na_2SO_4 and NaOH) used in group and fractional analysis of soil humus were first freed of "traces" of ammonium nitrate: b) N was determined separately in alkaline extracts and in the humic acids; the nitrogen content of the fulvic acids was determined from the difference.

The distribution of nitrogen in the deeper subhorizons of the dark-gray soil has a marked similarity to the group distribution of the humic substances. The nitrogen group extracted with the humic acids dominates, followed in descending order by available nitrogen as-

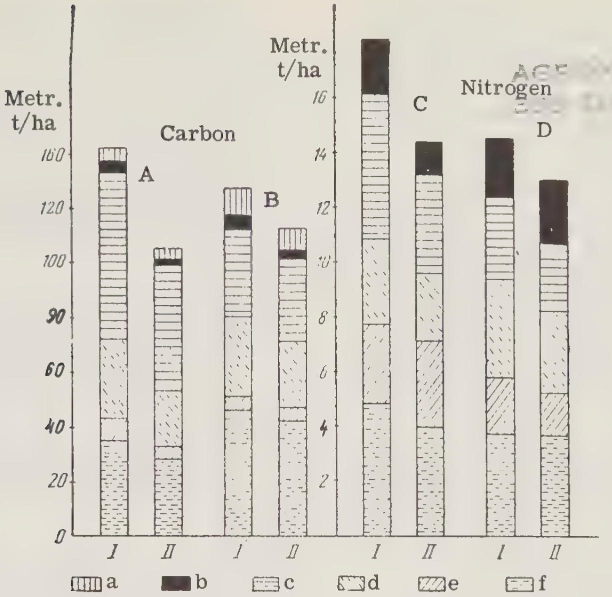

Fig. 1 - Total contents of carbon and nitrogen in humic substances in a 40 cm layer of the soils studied.

A - dark-grey forest soil; B - residually podzolized-solodized solonetz; C - dark-gray forest soil; D - residual podzolized-solodized solonetz. I - plot with litter; II - plot without litter. a - wax-resins; b - substances soluble on decalcification; c - humic acids; d - fulvic acids; e - substances hydrolyzed in 0.5-1.0 n H_2SO_4; f - soil humus humins.

sociated with fulvic acids and finally by nitrogen compounds intimately bonded with the nonhydrolyzed residues of the soil humus.

A comparison of the qualitative and quantitative composition of organic matter in a 40 cm layer of the experimental plots (Fig. 1) shows that the group composition of nitrogenous matter varies unequally on plots without litter.

The absence of litter on the ash-gout weed-oak stand plot is most clearly reflected in a decline in easily soluble forms of nitrogen extracted by a normal solution of sodium sulfate. Next comes the group of nitrogenous substances associated with the humic acids, the fulvic acids and the nonhydrolyzed residue. In addition to a general decreased content of nitrogenous compounds in the soil there is a certain absolute increase in the group of substances that are hydrolyzed by cold 0.5 n H_2SO_4 and by heated 1.0 n H_2SO_4. This increase is not due to the entry of organic substances with the solution, but is associated with a regrouping of forms of varying availability in the composition of the humus.

In the soil without litter beneath the solonetz oak stand there was only an insignificant increase in the content of easily soluble nitrogen compounds (by 132 kg/ha) and its content declined sharply in the group that is hydrolyzed in sulfuric acid. These differences in the alteration of the group composition of nitrogenous substances in the podzolized-solodized by comparison with the dark-gray forest soil are caused by the special conditions in which organic matter is formed and converted in the soil of the solonetz oak stand: the hydrolyzed residue and humic acid groups are also less changed in this soil.

Conclusions

1. Forest litter plays a great part in the formation and accumulation of humic substances in soils.

2. Considerable changes took place in the content of the main organic components in soils beneath ash-gout weed and solonetz oak forests after they had been kept for 40 months without forest litter and grass. Thus the carbon content in the upper 40 cm of the

dark-gray forest soil decreased by 36.8 metric tons/ha and the nitrogen content by 3.74 metric tons/ha; in the residual podzolized-solodized solonetz the corresponding figures were 14.6 metric tons/ha for carbon and 1.55 metric tons/ha for nitrogen.

3. There is an unequal decline in the content of the various humic groups. The greatest decline in these soils is in the easily soluble carbon compounds that make up 54.6% of the humus in the dark-gray forest soil and 26% in the solonetz soils; the group of humic acids are more stable compounds in the humus complex and are followed in order of ascending mobility by the nonhydrolyzed residues or soil humins and so on.

The nitrogenous compounds are the least mobile in the group of soil humins. The difference in the nitrogen content of this group in the litter removed and not removed from soils is 18.9% for the dark-gray forest soil and only 2.2% for the solonetz soils.

4. The greatest loss of nitrogenous and carbon-containing substances in the dark-gray soil is in the group of compounds that are easily soluble (when the soil is decalcified), while in the residual solonetz soils it is in the group of substances that are hydrolyzed in 0.5-1.0 n H_2SO_4.

5. There are considerably greater losses of carbon and nitrogen-containing substances in the investigated layers of dark-gray forest soil in the plot with litter removed, where biological processes proceed under relatively optimum conditions, than in the same plot of the residual podzolized-solodized solonetz soil.

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BIBLIOGRAPHY

1. VILENSKIY, D. G. 1954. Pochvovedeniye Uchpedgiz.
2. ZONN, S. V. 1950. Geomorphological and soil conditions of forest growth in the Tellerman Experimental Plantation of the Forestry Institute of the USSR In: Tr. In-ta lesa AN SSSR, Vol. 3
3. ZONN, S. V. and A. K. ALESHINA. 1951. The dynamics and trend of the influence of oak forests on soils. In: Tr. In-ta lesa AN SSSR, Vol. 7. SSSR, Vol. 7.
4. ZONN, S. V. 1954. The influence of forests on soils. Moscow, Izd. AN SSSR.
5. KONONOVA, M. M. 1951. The problem of soil humus and contemporary methods for its study. Izd. AN SSSR.
6. KOSTYCHEV, P. A. 1884. The conditions under which chernozems are formed. In: Tr. Vol'no-ekonom. o-va, Vol. 3. St. Petersburg.
7. KRAVKOV, S. P. 1905. Aqueous solutions of the mineral components of plant remains and their interaction with the soil. Zh. Op. Agronomii, Vol. 6, No. 3.
8. LEVAKOVSKIY, S. F. 1888. Some additional studies of the chernozem. In: Tr. o-va inpyt. prirody pri Kharkovskom un-te, Vol. 12.
9. MINA, V. N. 1953. The interaction between forest vegetation and soils in various types of oak forest in the southern forest-steppe. In: Tr. In-ta lesa AN SSSR, Vol. 15.
10. MINA, V. N. 1954. The interaction between forest vegetation and the soil in the oak forests of the southern forest-steppe. In: Tr. In-ta lesa AN SSSR, Vol. 23.
11. MOROZOV, G. F. 1949. Forest theory. Moscow.
12. ORLOV, A. YA. 1955. Suctorial roots of tree species and the enrichment of the soil with organic matter. Pochvovedeniye No. 6.
13. PUSHKINSKAYA, O. I. 1953. Microflora of the soils of the Tellerman Experimental Plantation. In: Tr. In-ta lesa AN SSSR, Vol. 12.
14. RODE, A. A. 1955. Pochvovedeniye. Moscow.
15. SLEZKIN, N. P. 1900. Humus studies. Kiev.
16. SOKOLOV, D. F. 1953. The chemical nature of organic matter in the soils of oak forests. In: Tr. In-ta lesa AN SSSR, Vol. 12.
17. SOKOLOV, D. F. and S. S. FRANTSKEVICH. 1954. Changes in the composition of organic matter in soils beneath various forest plantations. In: Tr. In-ta lesa AN SSSR, Vol. 15.

. SOKOLOV, D. F. 1954. The composition of organic matter in the soils of oak forests. In: Tr. In-ta lesa AN SSSR, Vol. 23.

. STEPANOV, N. I. 1929. The chemical properties of forest litter as the main factor in natural rehabilitation. In: Tr. po lesnomu opytnomu delu, Issue 2.

. TYURIN, I. V. and YE. L. GUTKINA. 1940. Materials on the nature of "humins" in the chernozem. In: Tr. Pochv. in-ta im. V. V. Dokuchayeva AN SSSR, Vol. 23.

. TYURIN, I. V. 1946. The quantitative participation of active matter in the composition of the organic part of the soil. Pochvovedeniye No. 1.

22. TYURIN, I. V. 1951. Analytical procedure in comparative studies of the composition of soil mulch or humus. In: Tr. Pochv. in-ta im. V. V. Dokuchayeva AN SSSR, Vol. 28.

23. KHAN, D. V. 1945. The procedure for extracting the insoluble fraction (humin) from podzolized soils. In: Doklady vses. Akad. s.-kh. nauk im. U. I. Lenina, Issue 7-8.

24. HOPP-SEYLER, F. 1888, 1889. Über Huminsubstanzen, ihre Entstehung und Eigenschaften. (In German). Z. phys. Chem., Bd. XIII; Naturwiss. Rundschau, No. 7.

THE BRUSSELS WORLD FAIR OF 1958

M. G. Sushchevskiy

The World Fair in Brussels ran for six months. Its aim as defined by the organizers was: "to assist the development of activity in the intellectual sphere by visual comparison." The main theme was "Man and Progress" and the object was to: 1. Show what had been achieved for man throughout the world; 2. Throw light on the vital problems facing mankind; 3. Lead to better mutual understanding and comprehension.

The Brussels Fair was the first international exhibition since the war and the largest, both in the number of participating countries and in exhibition space (more than 500,000 m²).

Fifty-four countries and eight international organizations, including Organisation for Economic Cooperation, the Coal and Steel Board, Benelux, the International Red Cross, etc., took part.

Architecturally and in stand design, the largest and most original buildings were the pavilions of the USSR (22,000 m²), the USA (23,000 m²), Great Britain (21,000 m²), France (25,000 m²), and Belgium, which had 15 pavilions, 7 of which were devoted to her rich African colony of the Belgian Congo.

The Fair was attended by 45 million persons, a much higher attendance than at any previous national or international exhibition. Average daily attendance was 180,000 to 200,000, but the figures were highest in July and August when European workers on holiday were able to come.

We estimate that more than 30 million people (70% of the total) visited the Soviet pavilion, which opened promptly at 10 a. m. every day to the strains of the National Anthem. Even before opening time hundreds were waiting to be first in, to see and photograph our earth satellites and machines and the general layout of the exhibits. Within about an hour all the halls were already overcrowded. Free circulation was ensured in the Soviet pavilion, which held about 10,000, by the comfortable main entrance and several side exits and entrances.

The 18 sections of the Soviet pavilion were rich in natural exhibits, models, mock-ups, machines and instruments dealing with mechanical engineering, machine tools, radio engineering and television, agriculture and forestry, education, culture and sport, transport, and building.

All visitors to the Fair were delighted and amazed with our exhibit of the artificial earth satellites, the greatest achievements of Soviet industry and of the scientific and technical thought of our age. No other country in the world could compete with us in this respect. Even the most critical visitors acknowledged that our pavilion was unquestionably the best in content and in the richness and number of the exhibits, although some commented that we had too many exhibits and that several visits were necessary to take in the whole pavilion. It is true that to visit every stand entailed a daily walk of 6 km. The pavilion was open for 8 hours a day. The hours for being open were extended in some pavilions (the United States of America pavilion remained open until 11 p. m.).

There were 450 international gatherings at the Fair attended by some 250,000 people, including specialists. Soviet engineers, geologists, agronomists, flax growers, veterinarian and other specialists attended more than 50 meetings.

Communications were good. There were tr stops near the entrances on three sides. Withi the Fair itself the trams ran in tunnels so as not to hinder free circulation. The car parks were used by a million and a half private cars, 40,000 buses and 57,000 motorcycles. Helicopters giving joy rides made 6,000 flights between the Fair and the center of Brussels. Helicopters also brought 15,000 foreigners to Brussels. More than 1000 people went up in helicopters on the best day. These machines

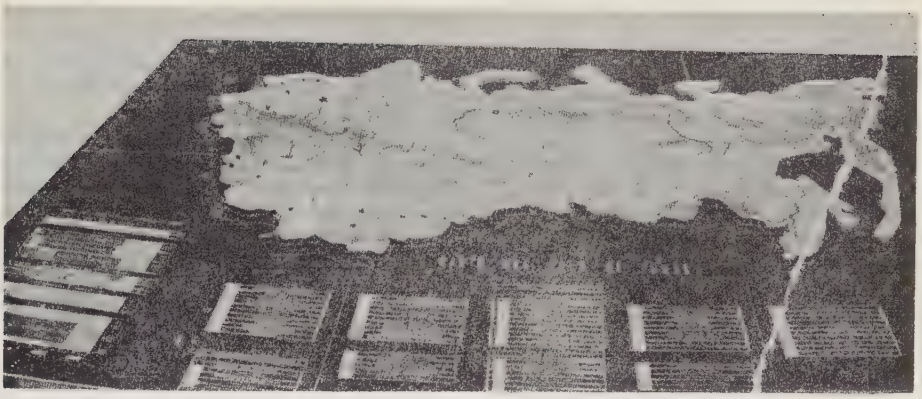

Fig. 1. - Stand with soil map of USSR at Brussel's Exhibition.

roved their use as a means of seeing the exbition and the town.

Nearly three million people went round the air on the suspension railway (telelift) and ere were also autocars which ran noiselessly the rails. One could go round the whole rea (200 ha) in them in 30 minutes and get a eneral idea of the layout before alighting at e stop of one's choice to see a pavilion. There ere also excursion cars, the majority of whose rivers know more than one language (French, erman, English and Spanish) and could therere converse freely with the passengers and t as guides. Press reports say that 5% of e visitors (there were 45 million) went to the ternational Palace of Science, in which our 2 stands were well attended.

The architectural masterpiece of the 1958 air was the "Atominum," which was visited 5 million people. The "Atominum" had the rm of an iron molecule magnified 160 thousand illion times. The structure was 102 m high d the globes were 18 m in diameter. The exbition was contained in its 9 round halls.

Since the United States, Great Britain and rance did not think it necessary to show their test work on atomic energy in the Fair and nce the Soviet Union also did not take part in e "Atominum," its exibits were not very inresting. Two of the globes contained a bar d a restaurant.

Progress in industry, transport, and build g was well revealed at the Fair. The Soviet vilion distributed 26 million leaflets, catagues, and prospectuses. There were few ands devoted to agriculture, which was not ally dealt with in some of the capitalist pavilns. Agriculture was given most space in e Soviet, Belgian, Dutch, French, and Arntinian pavilions.

The achievements of socialist agriculture were shown in the central hall of the Soviet pavilion together with machine tools and machinery and the artificial earth satellites. Model farms (kolkhozes, sovkhozes and M. T. S.), some Soviet experimental centers, the Soil Institute of the Academy of Sciences and a number of state plant-breeding stations were shown as agricultural exhibits.

To give the western visitor some idea of the fundamental socialist transformation of agriculture we decided to display the achievements and the life of the collective farmers in a Russian village of the Putilov-Glazat Kashin district of the Kalinin region (the "Krasnyy putilovets" kolkhoz).

This is a small kolkhoz which has included more than 500 households since the amalgamation of early 1958. The kolkhoz has extended its possessions and the number of members and increased the production of grain and technical crops and the number of cattle.

Good organization and cooperation have led to consistently high yields of wheat, potatoes, long-stemmed flax and corn from the poor sodpodzolized soils and to high incomes from the socialized economy. The milk yield of the kolkhoz herd is 3700 liters, and 553 cntr of milk and 70 cntr of meat are produced for each 100 ha of agricultural land. The income in 1957, which was more than 5 million rubles, enabled the farmer to pay 25 rubles for each labor day unit. Belgian and French farmers commented favorably on this farm. The economic information given on the photographs, diagrams, and models on the stand was carefully examined and copied down by visitors. Lively discussion was aroused by models of kolkhoz houses which were displayed on a raised platform. The houses of these collective farmers are well made log carbins that usually have two or three rooms. They are well furnished and supplied with electricity.

One interesting natural exhibit was some large sheaves of the long-stemmed flax grown on the farm. The usual yield is 9-10 cntr of flax fiber per hectare. There was considerable interest in this exhibit since many of the Belgian, Dutch, and French farmers also grow flax. Many of them asked us about growing conditions, soils, farming methods, and production costs. We also heard complaints that Soviet flax is sold at prices slightly below Belgian levels on the world market. It seems that manufacturers prefer to buy their flax from Soviet sources.

Many western visitors asked us to explain the difference between a kolkhoz and a sovkhoz. We were showing the "Tselinskiy" Sovkhoz in the Rostov region, which was set up in 1930 on several thousand hectares of the virgin arid steppe of the Sal district. The sovkhoz now farms 25,000 ha. No European or American country exhibited such a large unit. The sovkhoz produces winter and spring wheat, barley, sunflower, corn and all types of livestock produce and possesses 2,000 cows, 13,000 laying hens, and 11,000 pigs. The sovkhoz is well built. The brick factory produces up to a million bricks a month. The elevator, workshops, garages, houses, school, library, and other buildings are all brick-built and well equipped.

Visitors paid great attention to the interior of living rooms shown on a cross-sectional model of a single family house on the stand.

A soil map of the Soviet Union[1] prepared by the Dokuchayev Soil Institute of the USSR Academy of Sciences as a visual summary of soil research in the socialist period was placed at the center of the agricultural section.

The map distinguished 48 soil groups and a number of subgroups and species (based on the currently accepted classification on the State soil map of the USSR) and indicated the boundaries of the soil zones and the regions in which virgin and abandoned land are being brought into cultivation. The agricultural use of the soils and the main farming and land-reclamation techniques used in the soil zones were shown on the accompanying diagrams. The importance of the map for agricultural soil classification by districts and for general planning was explained in notes.

Next to the soil map was a large photomontage "The Development of Virgin Lands." Several American journalists and visitors said that the treatment of the virgin lands in the Soviet pavilion was a second "bombshell" (the first having been the Soviet earth satellites).

Information on the number of tractors, combines and other agricultural machines, to show our great advance over prerevolutionary Russia in the use of mechanical power, was given on the third stand. The achievements of kolkhozes in the Altay subdistrict served by the Zemlyanukhin M. T. S. were chosen as an example of mechanization. These kolkhozes have brought 15,000 ha of land under cultivation in the last three years and have increased the production of grain, sunflower, sugar beet, and other crops, thus considerably increasing cash income and the payment for labor day units.

There were many interesting models in the agricultural section, including one of the vegetable hothouses of the Moscow oil refinery whic are heated by waste steam from the plant. No other country exhibited an experiment of this type.

European and American visitors were greatly interested in a large model of an entirely mechanized four-row cow shed from the Kirov kolkhoz in the Kuntsevo district of the Moscow region and in a model of a 5,000-kw hydroelectric station.

Waste steam enables fresh vegetables to be grown cheaply during the winter in the hothouses of the Moscow oil refinery, where the production cost of it is only three to four rubles per kg.

The agriculture of Belgium, France, Hollan and other western countries is small-scale and in private hands. Farms do not usually have more than 10-15 cows and no farm in Belgium has as many cows as the Kirov kolkhoz nor, consequently, such a well organized cattle yard. It is only with such large-scale commun livestock farming that the latest advances in agricultural mechanization and electrification can be employed. Agriculture was dealt with in some detail in the Dutch and Belgian pavilions.

Holland exhibited high-yield Friesians. In all there were 28 cows, each yielding 6,000-7,000 liters of milk a year, on show. Progres in zoological technology has enabled the Dutch to raise the fat content of the milk given by their cows by almost 1% in the last 20 years. Cows with a fat content of 4%-4.5%-4.9% for a yield of 7,000-8,000 liters a year were shown at the Fair.

Pigs, chicken and even sheep were also shown in the Dutch pavilion. Since visitors showed great interest in live exhibits, the utch pavilion was always crowded. The workrs in the Dutch pavilion willingly passed on heir experience to visitors, including Soviet ourists.

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[1] The original map was drawn by N. N. Rozov assisted by Ye. V. Lobova, and edited by I. P. Gerasimov; this map was published by GUGK-MVD in 1956. The exhibit is described in greater detail in an article by N. N. Rozov in The Agricultural Journal (Zh. Zemledeliye), 10, 1958.

There was a very successful display of and-reclamation work in the Dutch pavilion. echanization has enabled the Dutch to win back 20,000 ha of land from the sea in the last 20 ears and to set up thousands of new farms. he government helps in the construction of oads, houses, barns, and cattle yards on hese lands. The peasant farms that are set up re sold on mortgage to young farmers. It ould, however, appear from the land utilizaion map in the pavilion that Dutch agriculture s in a state of crisis. Peasant economies have ecome very small and fragmentary and the maority of farmers are not able to use modern ractors and machinery. The government prooses to solve the crisis by amalgamating mall holdings into larger units, but the Dutch hemselves admit that there are "great diffiulties." The majority of small holders (2-5 a) do not wish to give up their holdings and eave their farms.

Since Holland is a maritime country a great eal of space was given to shipbuilding, the eas, coastal defenses and similar matters. working model of the formation of sea waves hich cause so much trouble to coastal deenses was one of the most interesting models the Fair. Waves the height of a man, prouced in a large glass tank filled with sea ater, roared noisily up a beach and rolled ack, creating a complete illusion of a rough ea and surf. Fascinated visitors spent hours t the model where they also saw navigational evices that measured the height, width, and orce of the wave. The model was viewed from n elevated (second story) platform above which, the dome, there was a large photograph of utch sea routes.

Belgian agriculture was well represented. he Belgian Ministry of Agriculture built two avilions to display agricultural machinery, othouses, seed beds, a garden, an orchard, nd a livestock farm containing live cattle beonging to Belgian farmers. There were alays 12-15 cows, several pigs, some poultry, nd even sheep (although sheep farming is poor developed in Belgium) at the livestock farm. ne agricultural pavilion was devoted to Belgium nd the other to the Belgian Congo. All the ows were local Belgian dairy and dairy-beef eeds. There were stands devoted to research stablishments, agricultural economics, and e life of the farmers. Selected seeds of ain, forage crops, vegetables, and technical ops and seed potatoes were displayed in one ll. It was no accident that one pavilion conined several outlines of the production and ficiency of mineral fertilizers. Belgian agrilture uses large quantities of fertilizer and manure. At a modest estimate Belgian farmers use an average of 20 cntr of fertilizer and 30-40 metric tons of manure per hectare of plowland. The Belgian chemical industry therefore produces large quantities of fertilizers, and others, such as potash and guano, are imported. Several factories process imported raw fertilizers (guano from Chile, sylvite from Germany, and phosphate rocks from Africa).

Less prominence was given to chemical weed and pest killers, although Belgian farmers and research establishments pay a great deal of attention to crop protection.

Belgian experimental stations had a prominent place. In its brief existence the experimental station at Gembloux has produced and is already introducing seven high-yield (40-45 cntr/ha) varieties of winter and spring wheat. According to the data of this experimental station, the mean protein content of the winter wheats sown in Belgium is up to 10%-12%. The protein content of the varieties shown in the Soviet pavilion was 17%-18% and this figure is exceeded in some Russian hard and strong wheats.

Interesting statistics on the country's agriculture were presented in the entrance hall of the Belgian agricultural pavilion. In 1957 there were, 1,717,213 ha of agricultural land, 813,912 ha of which were meadow and pasture. The area under forage crops is being continually expanded. Grain crops occupied 237,810 ha, sugar beets 62,440 ha, potatoes 82,191 ha, and orchards and flowers 76,796 ha. Unfortunately, although Belgium is a flax-growing country there were no figures for flax. Belgian farmers have long grown excellent flax, but no figures were given for the sown area since they fluctuate with market demand. Flax is only sown under contract to textile firms, which often prefer to import straw flax from France or the USSR.

Skillful farming and a favorable climate guarantee high yields of all crops to Belgian farmers. Data for the 1957 harvest were given in the pavilion. Average yields of wheat, sugar beets, and potatoes were 35.4, 400, and 228 cntr/ha, respectively. Yields of clover hay, alfalfa, vetch, root crops, and other forage crops are also high. Horse-beans are also sown as a forage crop and yield 30 cntr/ha. Owing to their high valuable for forage than corn, oats, or vetch.

The Belgians consume a great many potatoes. A special automatically ventilated potato store has been built next to the main buildings in the potato research station. The sides of the boxes in which batches of potatoes are stored are faced with airtight blocks. Farmers within a radius of 50 km send seed potatoes direct from the field to the potato store. Here they are sorted and cleaned in a highly efficient machine made in Holland. The potato store is the cooperative property of the farmers.

A large quantity of vegetables, fruits and grapes were exhibited in the Belgian pavilion. The Belgians grow desert grapes in hothouses. There are 38,000 greenhouses in one district near Brussels; some are heated and some are not. Belgian viticulturists have been growing several varieties of dessert grapes (Royal Muscadine, Gros Colmar, Muscat of Alexandria, and Leopold III) in these 20 x 7 x 3 m greenhouses for 50 years and fresh grapes are on sale in Belgian shops for most of the year. The grape harvest reaches 3-4 kg/m². Peaches, pears, plums, and other fruits are grown in similar greenhouses.

Belgian fruit farmers have also had great successes with pears. In an experimental station at Malignes we saw up to 300 varieties of pears being tested. Fresh vegetables and fruit were on display on the Belgian stands (grapes, pears, peaches, cauliflower, gherkins, lettuce, etc.) throughout the exhibition. This was the great difference between this pavilion and those of countries that were not able to bring their produce.

Belgium is a country of intensive livestock farming and one of the leading countries for head of cattle per 100 ha of farming land and for cattle productivity. Dairy, pig, and poultry farming are all highly developed. In 1957 Belgium had 2,999,000 cattle, including 1 million dairy cows, for a population of 8,900,000.

Poultry farming is highly developed. There were 16 million laying hens producing an average of 165 eggs each in 1957. There has been only a slight increase in the number of cows since 1900, but the milk yield has risen (from an average of 1700 liters per cow in 1900 to 3650 liters in 1957).

There were 15 cows on show in the livestock farm. The Belgians usually keep their cows untethered on litter. The cows are mechanically milked in a separate shed, to which they come at a fixed time for an additional ration of concentrates. Udders and hoofs are washed on the move by a machine controlled by a photocell. On their return from the milking area the cows are sprayed with a fly killer. There are therefore no flies on the farm. The cows are milked three times a day. In the cattleyard an "electric cowherd" separates the milked from the unmilked cows. Coarse forage and concentrates are usually stored in a loft for ease of distribution to the racks. The six breeds of cattle in Belgium were shown in the pavilion on a raised relief map of the country divided into six zones, each of which had a wax model of the breed.

Equipment for a 15-ha farm was displayed in an open area beneath an awning. The Belgian Ministry of Agriculture thinks that a farm of this size should have an 18-hp tractor, two or three hydraulically operated four-frame plows, milking equipment and machines, a separator and churn, a mowing machine with side rakes and baler, and hay dryer.

The Belgian Ministry of Agriculture is promoting an interesting, cheap cowshed, two walls of which are lined with baled hay and the third of which is a silage feeder. When kept indoors the cows feed from the hay "walks." The walls are prevented from being trampled by an adjustable fence which is moved back as the hay is eaten. The roof is supported at the corners by pillars.

A model of a cattleyard designed by Professo Hinbeck of the University of Louvain was on display. The yard was designed so that one man working an 8-hour day can look after 15 cows and 20-pigs. The cows are free to enter and leave and spend more of the day at pasture, returning to the yard for concentrates and milking. Forage is kept in special silos above the stalls and pumped through a tube by a specia motor operated by the cowherd.

There was a large agricultural hall in the Argentinian pavilion. Agriculture (like oil) is of great importance to the economy. Some agricultural statistics for 1957 were displayed in the entrance hall. Sown areas (thousands of ha) were: wheat, 6,000; corn, 4,000; barley, 1,400; oats, 2,000; flax, 1,300; cotton, 0.650; sugar beets, 0.400; sunflower, 0.300.

Wheat and corn bulk large in the 16 million ha of grain crops in Argentina and the area under industrial crops (oil flax, cotton, sugar beet and sunflower) is also large. The sown areas for tea (31,000 ha) and tobacco (44,000 ha) are also being extended. There is a large area of orchards and berry fields and commercial production of olive soil has been started. Argentina's main exports are however grain, meat, wool and leather and she possesses 44 million cattle, 45 million sheep and 4 million pigs.

The Argentinians produce a great many beef cattle. A series of photographs showed prize-winning herefords, shorthorns and Aberdeens.

The sheep are mainly Romney Marsh, Lincolns and Merinos. One stand had a large poster which asserted "The whole world eats Argentinian meat" and a table of meat exports in 1957.

The Soviet Union buys leather from Argentina and has also taken small quantities of meat (about 3,000 metric tons) in recent years.

Figures on meat consumption in various

countries were given in the agricultural hall. Meat is the staple diet of Argentinians.

Argentinian grain production was not shown n the exhibition but considerable space was given to grain exports, elevator construction and seed growing. Underground grain storage was said to be coming into general use.

In 1957 the capacity of underground storage was more than 2 million tons. A storage consists of double rows of 20-40 containers up to 100 m and more long, 8-10 m wide and 1.5-2 m deep. The sections are filled directly from ruchs through hatches in the roof. Similar grain stores might replace the cumbersome and expensive elevators that require so much iron concrete in our country, especially where the ground water lies deep.

The Czechoslovak agricultural hall was well planned. There was a large diorama of he planting of hops, of which there are 10,000 ha in Czechoslovakia, laboratory equipment for he production of malt and a wheeled tractor, he first product of the Czech tractor industry.

There are some 600,000 ha of barley in Czechoslovakia, the majority of which is used o produce the world famous Pilsener beer. One stand was devoted to the history and production of Pilsener and to laboratory, factory and storage equipment. There were some colorful photographs of the hop festival. The Czechs won first prize (the Grand Prix) for heir hops at the Fair.

There was a separate agricultural hall in he Hungarian pavilion. Dessert cherries, rapes, plums, apples, cauliflower and other ypes of fresh produce were kept on display in he pavilion as was the famous Hungarian Tokay wine.

Considerable space was also given to agriulture in the French pavilion. Renault tracors, new combines and two reaper-binders were demonstrated in a special enclosure. All he tractors and combines were air-cooled as he British, French and American tractor plants efuse to produce water-cooled tractors. There were various groups of agricultural machines n the French pavilion, including, in particular, new binding attachment for reapers and pneumatic seeding machines for corn. French, elgian, Dutch and other West European armers use a lot of straw for litter in cattle-ards and therefore bale and haul it at harvest ime. Combine straw is not scattered as in he United States and other countries but is sed in accumulating manure.

There was a small section of slides on mechanization prepared by Massey-Harris-erguson in the British pavilion, but only an utline of the work of this firm and a few of its machines.

Many visitors wanted to learn something about American agriculture but very little space was given to the subject in the United States pavilion. We cannot understand why three sorts of tumbleweed were displayed under the caption: "When broken away from its roots this plant can travel up to 100 km in a day if it does not come up against an obstacle."

Corn, of which there are more than 400 million ha in America, was represented by three small cobs of a local variety and the caption: "Corn was cultivated in America long before the arrival of the Europeans." There were also five potato tubers that had been chemically treated to prevent germination displayed under glass on a small pedestal. In the middle of the floor there was a primitive wooden roller which the authors felt certain was the prototype of at least a combine or a thresher. We were all surprised to see a sculpture of death with a scythe in the agricultural section. Many visitors asked the American guides the reason why but they could not explain.

A number of prizes and awards were instituted at the Brussels World Fair. More than 40 international juries, which included workers from the Soviet pavilion, judged the exhibits. The Soviet Union, Belgium, Holland, France, Argentina, Italy, Brazil, Czechoslovakia, Luxembourg, Monaco and the United States, British, Canadian, Spanish, Portuguese, Turkish, Austrian and Finnish pavilions entered the agricultural section. The Soviet pavilion received the largest number of prizes and awards for agriculture. The jury very objectively and decisively rejected insignificant and badly displayed exhibits, whatever the country of origin. The exhibits from Luxembourg, for example, failed to gain enough points although the quality of its cheese, butter and wine is known throughout Europe. The agricultural exhibits from Luxembourg consisted of stained glass panels.

The exhibits entered for the competition were judged in relation to their usefulness, quality and external appearance. There were five grades: Grand-Prix, Diploma of Honor, Gold, Silver and Bronze medal.

The jury unanimously awarded the first Grand-Prix to the Ministry of Agriculture of the USSR for its exhibit "Rural Economy" presented as statistical diagrams (expansion of sown areas, growth of agricultural commodity production, increase in number of cattle and growth of the income and standard of living of collective farmers), for its depiction of the achievements of the "Krasnyy Putilovets" kolkhoz, the "Tselinskiy" sovkhoz and the

Zemlyanukhin M. T. S. and for the opening up of 36 million ha of virgin land.

The diagrams were supplemented by documentary photographs and natural exhibits. One member of the jury showed great interest in the incomes of the collective farmers and workers, their cultural development, education, private property and similar questions.

The research establishments of the USSR Ministry of Agriculture were awarded a Grand-Prix for scientific and practical work on new grain, technical, oil, vegetable and forage crops, which were represented in the pavilion by 120 top grade samples of the seeds and 40 sheaves of different crops.

The Stalingrad tractor plant and the designers of the DT-56 and DT-57 tractors were awarded a Grand-Prix. The DT-57 was demonstrated with 2 plows for plowing steep slopes.

A Grand-Prix was awarded to the Taganrog factory and the designers of the SK-3 self-propelled combine. The Giprosel-elektro Institute received a Grand-Prix for a working model of a 500 kw rural hydroelectric station. A new honeycomb structure effects a 50%-60% economy in cement and a 25%-30% reduction in construction costs in the dam. These dams do not require casings and trestles and can be produced industrially.

The Dnepropetrovsk plant and the designers of the SKEM-3 beet harvester received a Diploma of Honor, as did the Gomsel'mash plant and the designers of the UKSK-2, 6, corn silage combine and the Moscow oil refinery for their model of an arched vegetable hothouse using industrial waste steam and carbon dioxide.

Diplomas of Honor were also awarded to the Minsk tractor plant and the design teams of the MTZ-5M and MTZ-7 tractors, the Kirovgrad "Krasnaya Zvezda" plant and the designers of SOK-2 and 8A vegetable seeders, the SKGN-6V square cluster planter and the SUL-48 flax seeder, and to the Kharkov tractor plant for the DT-20 and DT-16G (caterpillar) tractors and the self-propelled chassis DVSSh-16.

The Dokuchayev Soil Institute was awarded a Gold Medal for its soil map of the USSR as was the Vladimir tractor plant for the DT-28-2 and T-28-3 tractors.

Silver medals were awarded to the Moscow "Agroposobiye" plant of the Ministry of Agriculture for wax models of the best and most widely grown Michurin and traditional apples, and to the Ministry of Agriculture for a mounted exhibit of astrakhan rams which had attracted the attention of Belgian, French and British visitors.

In all, the Soviet pavilion received more than 500 awards and the staff of the pavilion were jointly awarded the Gold Star of the World Fair for the content and presentation of their exhibits.

Soviet participation in the Brussels Fair was based on the ideas of peace, friendship and peaceful coexistence. The Fair enabled millions of people to gain a better understanding with the achievements of other peoples.

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CHEMICAL METHODS FOR THE DETERMINATION OF AVAILABLE POTASSIUM IN SOILS

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In view of the present extension in large-scale soil mapping and the evaluation of the land (site quality) and of the increased use of mineral fertilizers in agriculture, we are even more in need of reliable methods of chemical soil analysis that are rapid, simple and inexpensive.

Existing methods for determining potassium for characteristics of soil and establishing requirements of potassium fertilizers are inadequate. Since, however, potassium is one of the "three major elements," chemical analysis of the soil before applying potassium fertilizers is of importance. Nitrogen is an almost universal requirement and it is therefore difficult to make any mistake in its application. The phosphorus requirement (if nitrogen is available) is also extensive, but the effect of potassium and, consequently, the value of applying potassium fertilizers can only be determined from prior chemical analysis of the soils (or the plants).

Table 1 enumerates methods for the determination of available potassium that have been developed and are employed in the Soviet Union.

The majority of these methods were put forward 20 to 25 years ago and are based on he determination of available potassium exracted from the soil by a salt solution or weak acid. In all the methods, except Maslova's, the potassium is precipitated in the form of potassium-sodium cobalt nitrite and determined by volumetric or nephelometric analysis. In Peyve's method the potassium is also precipitated as potassium-sodium cobalt nitrite but is determined by the minimum concentrations method.

The main fault of the majority of methods is heir low productivity. The more productive methods of Peyve, Golubev and Krumin'sh are not very accurate and the results are difficult o reproduce.

Table 2 summarizes the chemical methods used in foreign countries to determine available potassium (16, 19, 20).

The table shows that a wide range of solvents — organic acids, mineral acids in various concentrations, neutral salts and various buffer solutions — is employed.

Morgan's method of extraction and determination by flame photometry or more rarely by nephelometry is most common in Britain and the United States. Potassium is also widely extracted in the U. S. A. by ammonium acetate (Peech's method) and in Britain by ammonium nitrate (Cambridge) and determined by a flame photometer.

In Germany (and recently in Denmark, Hungary and Poland) the main method is the Egner-Riehm method of extracting potassium from the soil with a solution of calcium lactate followed by flame photometry.

In France the main solvents recommended are 1.0 N ammonium acetate (Antibes, Amiens) and Morgan's reagent (Gargenville) and the potassium is determined in a flame photometer.

Potassium is extracted by 0.1 N HCl in Holland (soil: solution ratio 1:10), by 0.5 N ammonium acetate (1:10 ratio) in Denmark, and by a buffer mixture of 0.1 N CH_3COOH + 0.005 N $Ca(CH_3COO)_2$ (1:10 ratio) in Sweden: in each case the potassium is determined in a flame photometer.

The spectral method of determining potassium in soil extracts in a flame photometer, which is simple, rapid, cheap and accurate, is undoubtedly the main method used in the USSR. Up to 400-450 potassium assays a day can be made with special flame photometers (14, 15).

What extraction methods should we recommend for future use by the Soviet chemists?

Table 1

Methods for the determination of available forms of potassium in the soil

Author's method and years	Soils	Solvent	Soil: solution	Duration of shaking	Method of chemical analysis
Kirsanov [8], 1933	Sod-podzolized	HCl 0.2 n	1:5	1 hour	Volumetric
Krumin'sh [9], 1933	Sod-podzolized	$NaNO_3$ 2.5 n	1:2,5	5-10 min.	Nephelometric
Maslova [10], 1934	Various soils				Volumetric
Peyve [11], 1935	Sod-podzolized	CH_3COONH_4 1.0 n NaCl 1.0 n	1:10 1:2	1 hour 5 min.	Least concentrations
Guseynov [5], 1935	Carbonate				Volumetric
Bamberg [1], 1936	Sod-podzolized	$(NH_4) SO_4$ 1.0 n HCl 0.01 n	1:5 1:5	15 min. 1 hour	Volumetric
Brovkina [2], 1936	Chernozems				Peyve's method
Protasov [12], 1939	Carbonate	HCl 0,2 n	1:5	1 hour	Volumetric
Golubev [4], 1941	Sod-podzolized	$(NH_4)_2CO_3$ 0.2 n $NaNO_3$ 10%	1:10 1:10	5 min. 1 hour	Nephelometric
Zhorikov [7], 1952	Carbonate	Ca (HCO_3) + CO_2	1:20-50	3 hours	Volumetric
Dashevskiy [6], 1955	Grey-earths	$MgSO_4$ 0.03%	1:10	1 hour	nephelometric

Table 2

Chemical methods of extracting available potassium from soils

Extraction solutions[a]	American	Britain	Belgium	Germany	Denmark	Netherlands	Norway	Italy	Sweden	Turkey	France
HCl, HNO_3, H_2SO_4 0.002 — -0.2 n (Truog, Hibbard, Fraps, et al.)	+	+				+		+			+
Carbonic acid (H_2O + +CO_2)						+					
Citric acid (Dyer, Kenig-Hazenbaumer)		+		+						+	
Acetic acid		+									
$Ca(HCO_3)_2+CO_2$ (Dirks and Schaffer)		+		+				+			
Mg $(HCO_3)_2 + CO_2$ (Dreispring-Heinz	+			+							+
$CH_3COONa + CH_3COOH$ (Morgan)	+	+	+								
CH_3COOH + Ca $(CH_3COO)_2$ (Egner 1940)		+					+		+		
$CH_3COONA + HNO_3$ (Bray)		+									
CH_3COONH_4 (Peech, Truog and Volk)	+				+						+
Ca lactate + HCl (Egner-Riehm)			+	+							
NaCl, $NaNO_3$, NH_4NO_3, NH_4Cl (Banddorf, Nehring, Keranen Seidel)		+		+	+			+			

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[a] Procedural instructions. Chemical methods for soil study. Acad. Sci. USSR Press, 1954.

Since available potassium is the main source for the potassium nutrition of plants, its determination should be taken as the basis for characterizing soil. The quality of the method depends on the degree of extraction and the universality of the solvent (for different soils). The exchangeable potassium content of the soil is not only an index for the supply of available potassium but also the amount of adsorption complex (amount, dispersion, mineralogical and chemical composition).

The extraction methods are compared in Table 3. The author's instructions were followed when extracting potassium by the methods of Maslova, Peyve, Kirsanov (and Brovkina), Guseynov and Protasov (5, 9, 10, 11, 12); in the Egner-Riehm method 5 g of soil are shaken up with 250 ml of the calcium lactate solution, which has pH 3.65, for 1-1/2 hr. In the Schachtschabel method (18), which is the main method used in Czechoslovakia, 20 g of soil are periodically shaken (10-12 times in 24 hrs) in 50 ml of a solution of 0.8 N CH_3COONH_4 + 0.2 N $(NH_4)_2 x C_2O_4$ with pH 6.8-6.9. The potassium in the filters was determined in each case by the Ivanov method of flame photometry. The quantities of potassium obtained were compared with the exchangeable potassium content removed from the soils by repeated washing with a 1.0 N solution of ammonium acetate.

The most satisfactory results were obtained with 1.0 N ammonium acetate using Maslova's method. An average of 75% of the total exchangeable potassium was extracted from the soils on shaking for 1 hr at a soil:solution ratio of 1:10. In particular, this solution extracted approximately equal amounts (in relation to the total amount) from all the soils studied, although they were of different genetic composition and texture. This is due to the wide buffer range of the solution, the comparatively wide soil:solution ratio and to the high exchange energy of the ammonia cation.

The Peyve method was least satisfactory. Owing to the narrow soil:solution ratio (1:2) and the brief reaction time (5 min), only a small part of the exchangeable potassium is extracted from fine textured soils. The Guseinov and Protasov methods gave comparatively good results.

The Egner-Riehm lactate method gives a high average extraction (70%), but the results are overstated if the exchangeable potassium content is low, owing to the wide soil:solution ratio (1:50). Stable results but smaller quantities of exchangeable potassium (57%) were yielded by the Schachtschabel method which is simpler and more practicable than the Egner-Riehm method. Similar results (not given) were obtained with the Maslova method when the soil:solution ratio was increased from 2.5 to 10: the highest figures for exchangeable potassium in all the soils (80%-86%) were obtained when this ratio was increased to 1:25.

Table 3

Comparison of various chemical methods for extracting available forms of potassium from soils

Soil	Extraction methods and K_2O content in mg per 100 g of soil										
	Total	Exchangeable	Maslova	Peyve	Kirsanov (Brovkina)	Guseynov	Protasov	Egner-Riehm	Schachtschabel	2.0 n $NaNO_3$	
										Spectral	Sedimentation analysis
Sod-podzolized sandy	1322	6.0	4.3	3.1	3.7	4.0	3.8	6.5	3.5	6.0	6.0
Sod sandy loam	1632	6.8	4.9	3.6	4.1	4.0	4.1	7.8	3.8	6.6	6.0
Sod coarse clay loam	1658	26.2	19.6	10.8	17.3	18.4	16.9	19.0	18.3	25.1	22.0
Sod fine clay loam	1780	21.1	13.3	5.0	8.1	9.4	8.4	10.1	9.0	12.2	14.0
Grey forest	1983	32.9	24.7	7.3	17.4	21.0	19.6	19.9	19.9	23.2	23.0
Medium clay loam chernozem	1896	20.1	15.1	3.1	10.0	13.1	10.5	11.5	11.3	12.8	12.0
Fine clay loam chernozem	1958	73.5	60.8	9.9	38.9	46.8	45.6	38.5	44.7	44.1	42.0
Coarse clay loam chestnut	2880	24.6	17.0	5.9	14.8	14.2	13.4	16.2	13.7	19.1	17.0
Sierozem	—	40.8	32.3	10.2	14.3	27.3	26.5	25.5	25.1	39.7	30.0
Red earth	1036	41.9	33.0	7.2	13.8	12.9	12.6	17.4	16.8	35.2	30.0
Yellow earth	—	7.8	5.7	2.6	3.6	4.5	3.3	6.6	4.2	6.7	8.0
Alluvial-meadow	1910	60.0	46.4	11.0	21.4	37.2	36.9	34.5	45.7	50.0	46.0

We concluded from our investigations that, when using a flame photometer, a 1.0 N solution of ammonium acetate is the best reagent. The advantage of the reagent are its availability, purity (from potassium) and ease of analysis. The Schachtschabel method is equally good (at 1:10) but requires an additional reagent (ammonium oxalate). There is no need to remove the calcium when using an Ivanov flame photometer and the introduction of ammonium oxalate into the solution is therefore superfluous.

Previously recommended methods should continue to be used until the flame photometer comes into general use: the Peyve method for soils other than chernozems, the Brovkina method (a combination of the Kirsanov and Peyve methods) for chernozems and the Guseynov and Protasov method for carbonate soils. The retention of the Peyve method is also due to the fact that the corresponding "limits" for the supply of potassium in the soils have been worked out.

For the sake of speed the potassium in soil extracts will probably be determined by nephelometry or by Peyve's minimum concentrations method. These methods are not sufficiently accurate. Visual determination of turbidity or "minimum concentration" is very subjective and the influence of temperature complicates the use of these methods. Peyve considers that in the 12-24°C temperature range the minimum concentration of K_2O in mg per liter of solution is approximately equal to the temperature expressed in degrees. We only found close agreement in the range 18-20°C (Table 4).

The solubility of potassium coblat nutrite at low temperatures is slight and falls off more rapidly than the decline in temperature. At temperatures above 20-22°C, on the other hand, the increase in solubility is more than proportional. At 26-30°C the solubility of the precipitate is great enough to affect the accuracy of the analysis and to make it impossible if the potassium content of the solution is slight.

Before the general introduction of the photometric method abroad (Germany, Italy, etc.) a sedimentation method was used, by which the potassium was determined from the volume of the potassium-sodium cobalt nitrite precipitate in a capillary tube. The results obtained by this method in a 2.0 N extract with $NaNO_3$ (soil: solution ratio 1:5, shaken for 1 hr) are given in the last column of Table 3 (13). These results are quite satisfactory and the method is the most suitable in the absence of a flame photometer, since it is direct, simple, rapid and sufficiently accurate.

We conclude from our investigations and our review of contemporary methods in other countries that an ammonium acetate solution is the most suitable reagent for determining (extracting) the exchangeable potassium in soils. Maslov's treatment — a 1.0 N solution used in a soil:solution ratio of 1:10 shaken for 1 hr — extracts up to 75% of the potassium from the most varied soils, including carbonate soils and is a highly productive and sufficiently accurate method when used in conjunction with a flame photometer.

If the method comes into general use for chemical characteristics of soils special studies will have to be made to establish the "limit values" for the supply of potassium in the soil that conform to this method.

Preliminary estimates for these "limit values' based on comparative study of the methods of Maslova, Peyve and others can already be given.

Table 4

Influence of temperature and time on the total precipitation of potassium[a] (in mg K_2O per liter of solution)

Temp. of solution on precipitation	Duration of reaction between solution and precipitant in hr.					
	1/2	1	2	4	8	24
10	6.2	7.1	8.4	8.8	8.6	8.4
14	10.0	10.6	10.4	10.8	11.1	11.6
18	19.6	19.2	18.3	18.2	17.4	17.2
22	24.3	24.0	23.5	23.0	22.5	22.0
26	32.6	32.5	31.3	31.3	31.5	31.6
30	44.6	45.3	46.0	47.1	48.3	50.3

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[a] Sodium cobalt nitrite produced by the Leningrad "Krasnyy khimik" chemical reagent plant was used to precipitate the potassium. The potassium was determined in a flame photometer.

n the paper by Maslova and Chernysheva (10), he exchangeable potassium content extracted rom various soils by ammonium acetate was -1/2 times greater on average than that ielded by the Peyve method. Countless assays arried out by the chemical laboratory of the Dokuchayev Soil Institute show that, on average, -1/2 times more potassium is extracted from od-podzolized soils by ammonium acetate han by the Peyve method.

The following "limit values" for exchangeable potassium (in mg of K_2O per 100 g of soil) can be provisionally adopted:

	Grain crops, flax, etc.	Root crops, potatoes, etc.
Poor soils inadequately supplied with potassium	<10 mg	<15 mg
Soils supplied with potassium	>20 mg	>30 mg

These "limit values" are confirmed by the results of a few field experiments. Fedorovskiy (14) suggests the following "limit values" from is studies of exchangeable potassium (by Masova's method) in the soils of field experiments n irrigated Rostov chernozems: < 14 mg K_2O er 100 g of soil, inadequately supplied with otassium, >30 mg — adequately supplied with potassium. In our studies in the pre-Baykal region (3) we took a potassium content f <10 mg K_2O (extraction by ammonium acetate and determination by a flame photometer) s being inadequate (<15 mg K_2O for irrigated oils). Brovkina (2) has provisionally suggested that, for sugar beet on chernozems, oils with <12 mg K_2O are inadequately supplied and those with >20 mg are adequately upplied with potassium. If we bear in mind hat Brovkina's method determines approximately 1-1/2 times less potassium than the mmonium acetate method, these "limits" for oot crops can also be accepted.

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BIBLIOGRAPHY

1. BAMBERG, K. K. 1955. Determination of active forms of calcium, potassium and phosphoric acid in the soil. In Agrochemical methods for studying soils. Izd. AN Latv. SSR, Riga.
2. BROVKINA, YE. A. 1936. The determination of soluble potassium in the soil. Tr. VNISP.
3. VAZHENIN, I. G. 1957. Chemical characteristics of the soils of Buryat Mongolia. Archives of the Buryat Mongol expedition of the Council for the Study of Productive Resources of the USSR. SOPS, AN SSSR.
4. GOLUBEV, I. K. 1941. Determination of exchangeable potassium in soils. Uch. zap. Mosk. in-ta zemleustroystva, No. 1.
5. GUSEYNOV, D. 1935. A new method for the determination of available potassium in carbonate soils. Khim. sots. zemled, No. 5.
6. DASHEVSKIY, L. I., T. P. ANTIPOVA, and O. M. NICHIPORENKO. 1955. Procedure for the determination of available K_2O in the soil. Tr. Otd. pochvov. AN Kirg. SSR, No. 5.
7. ZHORIKOV, YE. A. 1952. Chemical, Physical and microbiological research methods in irrigated cotton districts. Tashkent.
8. KIRSANOV, A. T. 1933. Chemical determination of soil requirement for potash fertilizers. Khim. sots. zemled. No. 6.
9. KRUMIN'SH, K. A. 1955. Field and rapid methods of chemical soil analysis. In: chemical methods for studying soils. Izd. AN Latv. SSSR, Riga.
10. MASLOVA, A. L. and Z. V. CHERNYSHEVA. 1934. The procedure for the determination of available potassium in the soil. Tr. VIUA, No. 5.
11. PEYVE, YA. V. 1935. The method for determining potassium in soils for chemical control. Khim. sots. zemled., No. 6.
12. PROTASOV, P. V. 1939. Methods for determining exchangeable potassium in carbonate soils. Pochvovedeniye, No. 5.
13. TURCHIN, F. V. 1954. Methods for determining available potassium compounds in the soil. In: Agrokhim. Metody issled. pochv. Izd. AN SSSR.
14. FEDOROVSKIY, D. V. 1958. An evaluation of the methods for determining available potassium in chernozems. Udobreniye i urozhay, No. 7.
15. BANDORFF, K. A. 1954. Rapid methods for the determination of potassium. Symposium. (In English).
16. Manures and Fertilizers. Potential

Potential Progress in Europe. (In English). 1954, O. E. E. C., Paris.

17. RIEHM, H. 1954. Flammenphotometrische Kaliumbestimmung im Laktextrakte ohne Ausfällung des Kalziums. (In German). Bodenkunde und Pflanzenernährung. Bd. 36, H. 1/2.

18. SCHACHTSCHABEL, P. 1941. Die Bestimmung des Kalibedarfs im Boden. (In German). Bodenkunde und Pflanzenerährung, Bd. 24, H. 1.

19. O. E. E. C. 1956. The organization and rationalization of soil analysis (In English), Paris.

20. THUN, RICHARD. 1955. Die Unterschung von Boden. (In German). In: Methodenbuch, B. I., Rodebcul und Berlin.

A RAPID METHOD FOR DETERMINING THE STABILITY OF MOLE DRAINS IN MINERAL SOILS UNDER FIELD AND LABORATORY CONDITIONS

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Mole drainage is one of the most economical methods for drying marshy or bog soils. Mole drainage, in conjunction with closed tile drains or alone, is widely used in Britain, where it has been successfully used for nearly 200 years[1] and in melioration in other countries. In the Soviet Union mole drainage has been shown to be highly effective in reclamation and in controlling salinity, (8) anaerobic conditions and other undesirable features.

The durability and effective life of mole drains depends on a number of factors including, in particular, the genesis of the soils, their texture, microstructure and mineralogical composition. The moisture at the time the drain is laid is another important factor. Mole drains can only be constructed in clay loam and clay soils. In friable soils (sands and medium humus sandy loams) the drains soon cave in. Mole drains may also become clogged in excessively wet clay loams and clays, even when other conditions are favorable to their construction. It is, therefore, usually recommended that mole drainage should be established in clay loams and clays with a moisture content within the plastic limits (4), (between the lower and upper plastic limits). These cases are also examined in the present paper. Low cost and ease of construction are important advantages of mole drainage.

Whether or not to use this type of drainage s decided by laboratory or field methods. Janert (12) has shown that when the dispersion of the soil is less than 8 (the degree of dispersion is equal to:

$$\frac{\Sigma \text{ fraction percentage} < 0.02 \text{ mm in diameter by Kopetskiy's method}}{\text{heat of wetting, cal/g}})$$

and the heat of wetting is not less than 4 cal/g, mole drains remain stable for a long time.

S. V. Astapov (1) has established that the ratio (ρ) of the sum of particles of 0.05-0.005 mm in diameter, determined by Pavlov's micro-aggregate analysis (9), to the sum of the same fractions by Kachinskiy's particle-size analysis (7) can be used to predict stability. When $\rho < 0.3$ the soil is undoubtedly suitable for mole drainage. The drains are somewhat unstable when $\rho = 0.3\text{-}0.7$, and when $\rho > 0.7$ the soils are unsuitable. This hypothesis has been verified by a number of workers (2, 11). The clearest indices were obtained (11) for soils in which $\rho < 0.3$, where all drains remained in excellent working condition, without any change in their initial diameter, for long periods. In the same or slightly longer periods the drain openings were eroded and their diameters varied greatly or they were completely filled in. Drains in soils in which $\rho < 0.7$ usually went out of order in 2-5 months.

In investigations in the Moscow, Ryazan', and Kalinin regions and in the Soviet Far East we obtained the clearest results at the limits of stability and instability ($\rho < 0.3$ and $\rho > 0.7$). The Janert and Astapov methods (1, 12) can be introduced if one has a well equipped laboratory and adequately trained analysts, since these determinations require time consuming analyses (initially the heat of wetting and micro-aggregate analysis in the one method and in another method particle-size and micro-aggregate analysis). The time and cost of each determination are so great that adequate characterizing the soil in the drainage area is often excluded.

In M. N. Glotov's field method (5) a hole 60-80 cm deep is filled with water to a level that ensures wetting of the soil horizon under investigation. The water in the hole is filled to a constant level throughout the observation period. If the vertical walls of the hole collapse within 30-40 min of wetting, the drains are completely unstable. If the vertical walls last for more than 8 hours the drains are stable. Depsite the simplicity of the method, its main drawbacks are the difficulty of ensuring water supply and the duration of each determination. When one remembers that reliable results call for parallel determinations in the profile of each soil type and a detailed description of the stability of each horizon in the soil stratum it becomes clear why this method is little used. It should also be noted that the method was not confirmed under Polish conditions, where drains lasted longer in rapidly collapsing soils than could be assumed from Glotov's ranges (10).

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[1] The first patent for a mole plow was granted in England in 1797 (13).

Owing to the large volume of mole drainage work on mineral soils there is clearly a need for sufficiently reliable but rapid and cheap diagnosis of the stability of mole drains during field soil melioration surveys. Accurate laboratory determinations of this index must also be extended.

From the foregoing the author has devised a rapid field and laboratory method for determining the stability of mole drains, which is based on numerical calculation of the rate of wetting of soil aggregates in water, since this allows the main factors governing the working life of the drains to be taken into account.[2]

A 300-400 g sample of soil is brought to air-dryness in a dry ventilated place (not in a thermostat or oven or in the sun if the temperature is more than 40-45°C) and sieved through a 5 mm opening sieve onto a 3 mm opening sieve. A 20 g sample of the 3-5 mm diameter aggregates is placed in a cylindrical metal container 20 mm high with a screen base and lid (0.5 mm opening grid). A detachable handle is fastened to lugs on the container (Figs. 1 and 2) and the whole thing is immersed in water in a vessel (140 mm tall) for 10 min so that the aggregates can soak. The sample in the container is then lifted up and down in the vessel 50 times in 1-1/2-2 min, each operation lasting for 1-1/2 sec) (Fig. 3). The container is then lifted out of the water and the holder is removed. The remainder of the sample is transferred to a filter, dried to air-dryness and weighed. The stability of the mole drains is characterized by the amount of the material (Table 2).

The object of the first series of experiments was to establish the relationship between the rate of soaking and the index in 38 bog soil samples from various districts in the RSFSR. The results are given below.

There was a considerable residue, varying between 4.6 and 19.3 g, for samples with the index $\rho<0.3$ (soils suitable for mole drainage according to Astapov). In all cases the residue consisted of well formed aggregates. Mole drains in these soils lasted well and functioned for not less than 3-4 years.

The soaking of the aggregates was quite different in soils in which $\rho>0.7$ (unsuitable for mole drainage according to Astapov). When sieved in water through a 1 mm mesh screen, 12 out of 14 samples disappeared completely or left a residue of not more than 0.3 g, while the remaining 2 left residues of 0.7 and 4.2 g. When sieved through an 0.5 mm mesh screen these two samples gave even greater residues (2.7 and 6.6), while the residues of the remaining 12 samples, consisting of small stones, iron concretions, small clay aggregates, roots and plants did not exceed 0.1-0.7 g. It should be emphasized that in those soils which were unstable according to the ρ index but which yielded considerable residues, mole drains functioned for a year, in the other case the drains were in good condition after 5 months use. These drains are now under repair. On the other hand, mole drains lasted only 2-3 months in soils which left a residue of less than 1 g after sieving in water.

Widely varying indices of soaking were obtained in the group of soils (13 samples) that were not sufficiently stable for mole drainage (ρ = 0.3-0.7). Four of them left quite significant residues consisting of clay aggregates on the 1 mm mesh screen, which the remaining 9 were completely decomposed. Sieving throug an 0.5 mm mesh screen showed the same type of soaking of the aggregates, except that somewhat larger residues were obtained from soils in which drains lasted for approximately a year (ρ = 0.51) than from soils with a similar value for ρ (0.49) in which the drains lasted only 2-3 months.

Thus soils, the ρ index indicating stability for mole drainage, have a low soaking rate and always leave large residues of aggregates. Soils that are unstable by this index normally disappear entirely when sieved in water, and soils in the group for which ρ = 0.3-0.7 may behave like either group. In this case it is very valuable to analyze the stability of drains in existing systems. Yangol''s paper (11), cited previously, gives data on the functioning of mole drains in the sod-podzolized clay loams of Ciscarpathia and the ρ indices at the depth o the drains. All drains in soils for which $\rho<0.3$ were in good order after 3 years of installation. When $\rho>0.7$ the drain openings were eroded after a few months or they became silted. On soils of the group for which ρ = 0.3-0.7, some of the drains were in good order after 5 months of use (the Engels kolkhoz - ρ = 0.52; the "Thirty Years of the October Revolution" kolkhoz - ρ = 0.63 and the Shevchenko kolkhoz - ρ = 0.63), while others were collapsed after 2-2-1/2 months (the Timoshenko kolkhoz - ρ =

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[2] When developing this method we used an instrument in which one screened box was attached to the handle. For mass analyses we recommend a holder with which the stability of two parallel samples can be determined (Fig. 1). The prototype of the apparatus was made by I.M. Khilenkov, an instrument maker in the Dokuchayev Soil Institute.

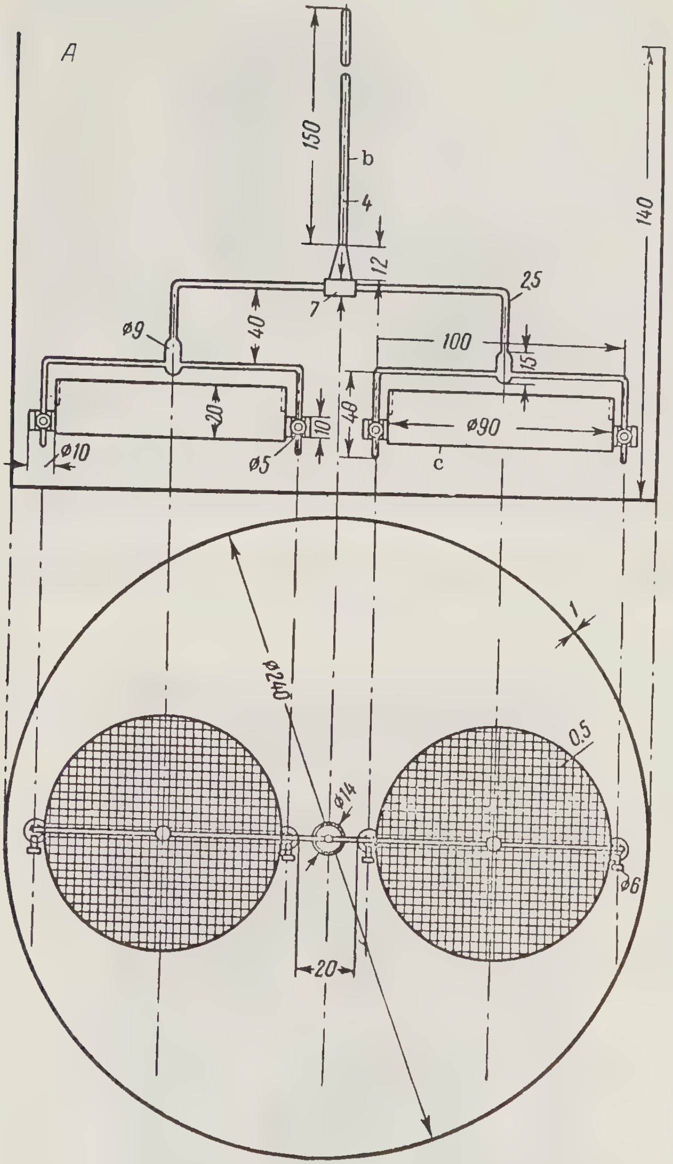

Fig. 1. - An apparatus for determining the stability of mole drains in soils from the rate of soaking of air-dry aggregates.

A - water vessel; B - holder; C - detachable cylindrical container with a screen base and lid.

0.56 and the Franko kolkhoz - ρ = 0.47).

We can therefore assume from Yangol''s data that the group of soils for which ρ = 0.3-0.7 contains soils with varying degrees of stability to mole drainage and that there is no direct connection between the magnitude of ρ and the stability of the drains within this group, i.e., there are cases in which drains may break down more rapidly in soils with a low ρ than in those with large ρ.

Samples for laboratory analysis were taken from 9 plots on various bog soils with existing mole drainage to clarify the connection between the real stability of the existing drains, the rate

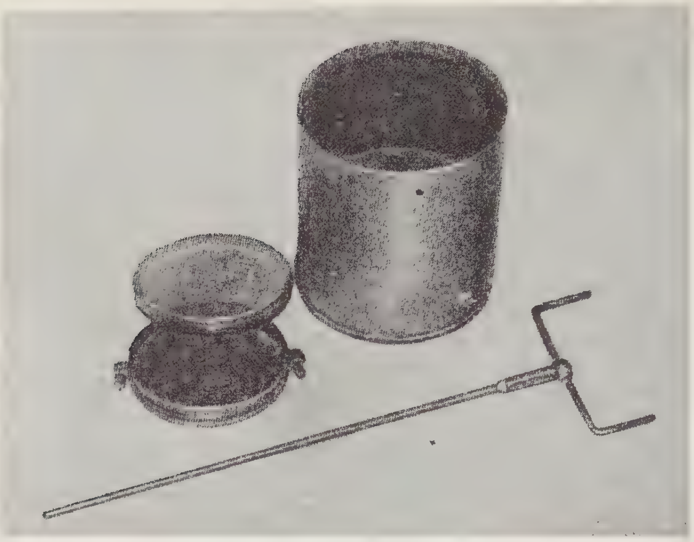

Fig. 2. - An apparatus for determining the stability of mole drains in soils from the rate of soaking of air-dry aggregates, dismantled.

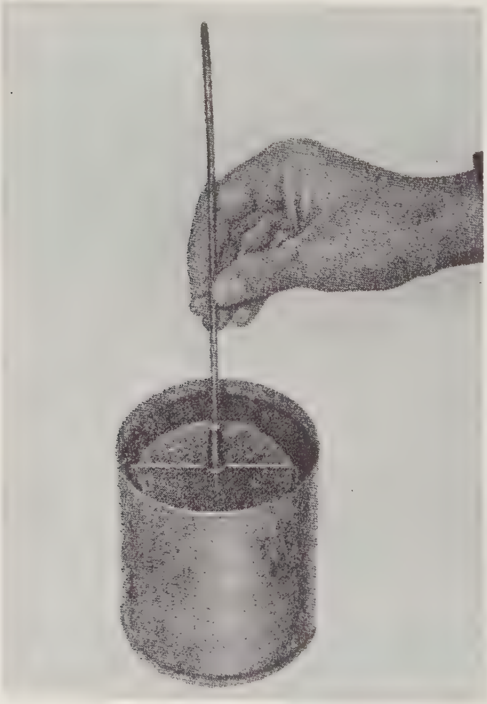

Fig. 3. - The apparatus assembled. Sieving aggregates.

of wetting aggregates and the ρ index. Drainage was in operation on some of the plots during the investigation period, while on others drains had been constructed in the early thirties and were now silted or destroyed, but adequate information on their functioning was available from the

Table 1

Effective life of mole drains in soil, the stability index and the amount of residue from soil samples after the wet sieving[a]

Location	Soil	Profile No. and depth, cm	Duration of mole drains	ρ	Particle content as a %		Residue (g) on the sieves of diam. opening, mm			Nature of the residue
					<0.01 mm	<0.01 mm	2	1	0.5	
Merteshevo Ryazan' region	Sod granular brown fine clay loam, B horizon	7 60-70	More than 2-1/2 years. Drains still in good condition and functioning	0.07	43.7	21.8	8.0	18.5	19.3	Aggregates well preserved after sieving in water
Yakhroma, Moscow Biological Experiment Station for Melioration, Moscow region	Sod granular brown clay, B horizon	102 45-55	More than 3 yrs.	0.02	82.6	43.8	—	11.5	14.6	"
Konchinino, Moscow region	Sod-gley clay, B horizon	104 45-55	More than 4 yrs.	0.11	77.9	33.0	2.5	8.5	11.8	"
Zapolek, Moscow region	Sod-gley clay	7 50-60	Sealed after first heavy rain	0.98	51.0	29.1	—	—	0.15	Some small orsteins
Ungun sovkhoz, Khabarovsk subdistrict	Sod-gley clay, B_1 horizon	106 25-35	Sealed after first rain	1.35	74.6	17.7	—	—	0.35	"
Lugovaya, Moscow region	Sod-podzolized clay, B_1 horizon	5 55-62	2-3 months	1.19	52.0	29.7	—	0.3	0.7	Large grain quartz sand
Sobakino, Moscow region	Sod-podzolized gley clay loam, A_2 B_1 horizon	1 50-60	" "	0.49	37.7	23.7	—	0.6[b]	0.8[b]	Quartz grains and small clay loam aggregates
Ungun sovkhoz, Khabarovsk subdistrict	Humus-gley clays, A_2 B_1 horizon	115 28-35	More than 5 months drains still in good condition and functioning	0.92	76.6	44.9	Not det'd.	4.2	6.3	Small clay loam aggregates
Barybino, Moscow region	Sod-podzolized clay, B_2 horizon	6 50-60	Drains functioning after 1 yr.	0.51	59.7	32.5	"	0.7	2.4	Small clay loam aggregates

[a] Samples were collected and field observations made on the Barybino, Zapolek and Sobakino systems by V. G. Vinogradov and on the other systems by the author. The analyst was N. G. Inyushkina.

[b] The weight of the clay loam residue is given for these samples. The total weight of the residues consisting of large grain quartz and small clay loam aggregates was 1.4 and 1.6 g, respectively

Table 2

Determination of the stability and durability of mole drains from the weight of air-dry samples after sieving in water

Drains function well for 3-4 yrs or longer	Drains function well for 3-4 yrs or longer	Drains function for 2-3 yrs and occasionally longer	Drains are not sufficiently stable and function for between 3-4 months months to 1 yr (2 yrs in exceptional cases)	Drains are quite unstable and collapse within 2-3 months of construction
Weight of residue after sieving, g	10-20	4-10	1-4	up to 1
Morphological nature of the residue after sieving in water	Well preserved large aggregates	Large and small aggregates	Small (~1 mm) aggregates	Small aggregates, orstein, stones, quartz grains

[a] In determining the weight of the residue after sieving in water only the weight of the clay loam and clay aggregates is considered. The weight of orstein, stones, quartz grains, etc. is excluded.

reports of the Lenin All-Union Agricultural Academy and published (6). The samples for analyses were taken from the same depths as the drains.

The results (Table 1) showed that $\rho<0.3$ on all 3 plots on which drains had been stable and had functioned for more than 2-3 years and that the residue of a standard (20 g) sample after soaking on an 0.5 mm mesh screen consisted of more than 10 g of well preserved large aggregates.

When drains had filled up shortly and had not functioned for more than 2-3 months after construction, ρ was usually >0.7, and the residue after sieving the aggregates in water did not exceed 1 g (Fig. 4). In individual cases there was a lack of correlation between the rate of wetting and the ρ index. Thus, mole drains in humus-gley clays were in good order and still functioning after 5 months. The residue of a sample taken from drain depth was 6.2 g, i. e, this index showed stability for mole

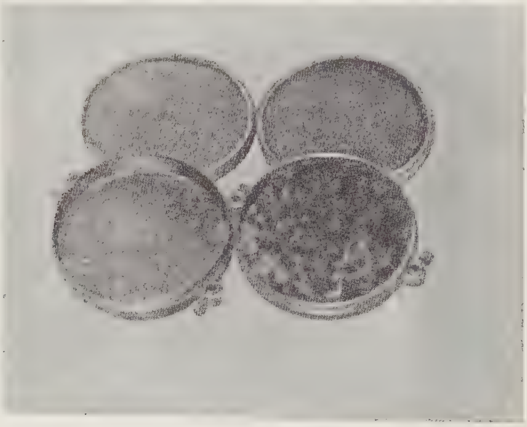

Fig. 4. - Aggregates after sieving in water. The sample at the left was taken at the depth of mole drains which had filled after 2-3 months functioning (the aggregates have completely disintegrated). The sample at the right was taken at the depth of drains that had been functioning for 2½ years (aggregates well preserved).

rainage, but the ρ index was 0.92. In one case rains in soils for which ρ = 0.3-0.7 became logged 2-3 months after construction and the lay loam residue after sieving in water on an .5 mm mesh screen was only 0.7 g, while in nother case they functioned for about a year and ıe residue was 2.4 g.

We therefore conclude that this method es- ablishes the over-all stability of the drains stable, unstable, insufficiently stable) and ıakes it possible to link the results with the urability of the drains. Thus a more detailed nd reliable prediction of the stability of mole rains than was possible with former methods an be made in some cases. The ranges in- olved are summarized in Table 2.

It should be noted that the values for the resi- ue given in Table 2 only hold if the drains are f good standard construction. It can be con- luded from the table that mole drainage is easible when the residue after sieving the ggregates in water is 10-20 g, but not in gen- ral when it is less than 10 g.

A feature of the method is that replications re in good agreement. Thus in 5 determina- ions of aggregates from profile No. 102 at 45- 5 cm, the weights of the residues were 14.6; 4.7; 15.0; 14.9 and 14.5 g. The arithmetic ıean of the residue is 14.7 g and the maximum eviation no more than ± 3%. The standard de- iation is 0.24 g. In different treatments of the xperiment mean arithmetic error was 0.11 g.

The cost of one determination of the stability f mole drains by this method is not more than rubles and the time for each determination .6 hr. The method is thus more economical ı both time and cost than the methods of Asta- ov, Janert and Glotov (5-5-1/2 times quicker ıan the Astapov and Janert methods and 13 mes quicker than the Janert method and 6-7- /2 and 13 times cheaper).

This is a field method which can also be idely used in the laboratory and which has ıe advantages of simplicity and economy. No pecial laboratory and reagents are required ıd the technique can be mastered by labora- ory assistants without high qualifications.

Much more attention must be paid than at resent to determining the stability of mole rains when making soil-melioration surveys bog mineral clay loams and clays, either ıring or after the survey, and the genesis of ıe soils must be carefully taken into account. he stability of mole drains in the vertical ofile of some typical cross-sections should described in detail, so as to select the ptimum depth for drain construction, since e existence of insufficiently stable horizons ove the drains has a negative influence on ırability and encourages silting. Finally, a collation map of the stability of soils in relation to mole drainage should be compiled.

We expect that our method will also be applied to soil-meliorative surveys for irrigation purposes, since the rate of wetting aggregates can also characterize the stability of the channels used for underground irrigation (3), but some additional research will be necessary.

CONCLUSIONS

1. A mass method is proposed for the rapid determination of the stability of mole drains in soils, based on calculation of the rate of wetting 3-5 mm diameter aggregates when sieved in water on an 0.5 mm mesh screen.

2. The method yields sufficiently clear and accurate data and replications are in good agreement.

3. Unlike present methods, this method enables one to establish both the stability of mole drains and their durability.

4. From the speed with which the aggregates are wetted, the determination is 6-7 times more economical than the Astapov and Janert methods and 12-14 times more than Glotov's method.

The method does not require qualified analysts or equipment and reagents that are expensive or in short supply.

5. The method can be used for field and laboratory work on soil melioration.

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BIBLIOGRAPHY

1. ASTAPOV, S. V. 1937. The stability of soil materials when laying mole drainage. Manuscript, VNIIGiM.

2. BABASHINSKAYA, V. A. V. I. YEVDOKIMOVA, and V. A. ROZIN. 1943. The effect of mole drainage on the water and air regime and fertility of soils. Stability of mole drains with non-supported walls. In the collection: Mole drainage. Sel'khozgiz, Moscow.

3. BOBCHENKO, V. I. 1957. Underground mole irrigation and the effect of artificial mole tunnels on the soil and plants. In: Biological principles of irrigation agriculture. Izd. AN SSSR.

4. VOSKRESENSKIY, M. N. and V. I. YEVDO-

KIMOVA. 1938. Permissible wetness of the soil when laying mole drains. In: Materialy po podnyatiyu proizvoditel'nosti sel'skokhozyaystvennykh zemel' posredstvom melioratsu, No. 5, Leningrad.

5. GLOTOV, M. N. 1939. The construction of drainage. Izd. VASKhNIL.

6. GLOTOV, M. N. 1943. Mole drainage and its use. In the collection: Mole drainage. Sel'khozgiz, Moscow.

7. KACHINSKIY, N. A. 1943. Particle-size micro-aggregate analysis of soils. Izd. AN SSSR, Moscow.

8. MUZYCHUK, I. 1957. Mole drainage in cultivating saline soils. Khlopkovodstvo, No. 10.

9. PAVLOV, G. I. 1930. The method of aggregate and microaggregate analysis of the composition of soils. Tr. Ak-Kavakskoy op. stantsii, No. 6.

10. SAKOVICH, F. I. 1956. The use of mole drainage in Poland (from materials in the Polish journal "Vodnoye khozyaystvo" for 1947-1956). Gidrotekhnika i melioratsiya, No. 11.

11. YANGOL', A. M. 1956. Mole drainage on the excessively moist soils of Ciscarpathia. Nauchn. tr. UkrNIIGiM, No. 77/3. Gossel'khozizdat Ukr. SSR., Kiev.

12. JANERT, H. 1932. Die Auforderungen des Maulwurfdränsverfahrens an den Boden. (In German). Verhandl. d. VI Kommission der Intern. Bodenk. Ges. Groningen (Holland).

13. NICHOLSON, M. A. 1934. The durability of mole drains. (In English). J. Agri. Sci. Vol. 24:2.

A NEW DETACHABLE SOIL AUGER

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Present day research makes ever greater lemands on the quality of soil samples taken vith augers. Samples taken from deep layers nust not be contaminated and the mixing of soil layers must be reduced to the minimum. The auger must be strong and reliable and easy o repair and maintain. It should preferably be ble to be serviced and transported by one man nd the quality of the samples should be similar o that of samples from soil pits.

The soil augers at present in use in Hungary lo not fully satisfy all these requirements. Open ugers collect contaminated samples while side-acing coincal devices with cutting edges deposit soil material on the bottom of the drill hole that ontaminates the samples (by 50%-100%).

Cylindrical augers require considerable hysical force; several people are necessary o turn them and to extract them from the soil.

The new type of soil auger answers the requirements. The head of the auger consists of wo casings hinged to each other. The retaining lates at the bottom of the casings are fitted vith welded or bolted cutting edges. The head loses in the direction of rotation. Chance pening is prevented by a retaining pin (Figs. 1 nd 2). Rapidly and reliably the rod or additionl rods for lenghtening is attached to the auger y thread. The device is completed by a shovel or removing the soil sample in the head of the uger. There is a spanner at the end of the hovel handle for removing the reinforcing screw.

The drilling equipment also includes a box rench and screw driver for assembling the olted parts of the head (cutting edges, hinge olts). It is advisable to have some spare utting edges although they only need replacing fter several months of work in dry, dense soil naterial. The equipment is contained in a canas satchel with leather edges.

The first and most fundamental advantage of ne auger is that the nearly horizontal disposion of the cutting edges makes it possible to take a sample from any depth. The hinged, side-opening construction guarantees unmixed samples — the new auger penetrates into dry tight clay solonchak much more rapidly than the old one and with considerably less effort. There is nothing to prevent sampling $CaCO_3$ concretions by the auger, since it either bores through them or presses them to the sides of the drill hole.

Premature wear of the casing can be prevented by replacement and resharpening of the cutting edges. The upper part of the head is circular and the lower part elliptical. The edges of the knives coincide with the major axis of the ellipse and the minor axis is the same as the diameter of the lower part of the head. This auger minimizes harmful friction that arises during drilling and the vacuum that develops when the auger is raised. The auger is strongly made and does not need special care. Therefore there is no need to use spiral weakening and enlarging augers. The use of sufficient one-meter ruled steel lengthening rods makes it possible to take samples from great depths as longas the opening are not filled by subsoil waters in the deep layers and solid rock is not encountered.

The average rate at which the auger penetrates into the soil is approximately 10 cm a minute. Unlike other similar devices, our auger does not have to be weighted when in use, nor is there any need to hammer it or use great pressure. The otpimum position of the cutting blades does away with the need for great physical effort. In clay and sandy soils the use of force "jams" the auger by so ramming the soil in the bottom of the cylinder that the gaps between the cutting blades become clogged and packed with soil.

The soil augers are used to take samples for laboratory work, in pile driving and when soil is being exploded and also, in some cases, for tree planting, setting up rods and pipes in the soil and general development and prospecting work.

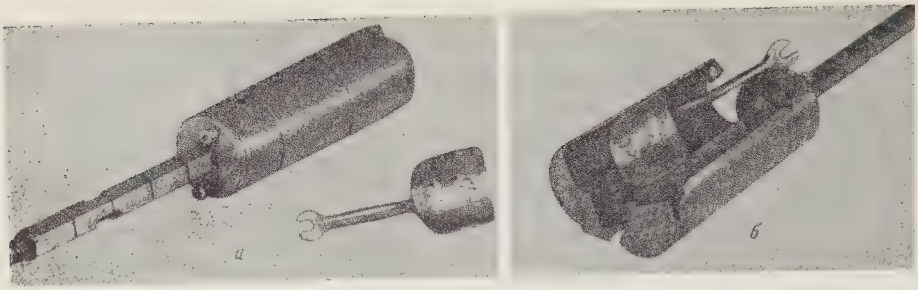

Fig. 1. - The new detachable soil auger. a - general appearance when closed; b - when open.

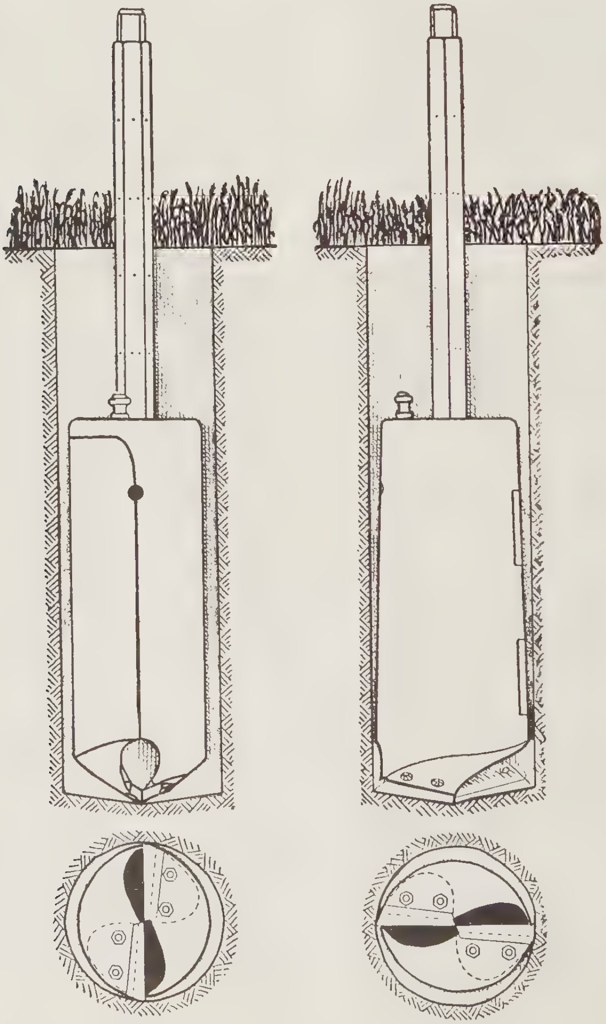

Fig. 2 - Diagram of the construction of the new soil auger.

The author's application for this new soil auger has recently been granted by the Hungarian State Committee for Inventions.

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A MECHANIZED AUGER FOR SOIL SAMPLING[1]

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The crude methods and equipment used in he field for soil drilling and make it difficult o take samples to determine moisture or chemcal analysis, especially in highly compacted oils or dried solonetz. It is often impossible o drill and take samples in the winter.

In our search for a mechanical soil drilling nethod we rejected rotary drilling owing to tructural complexity and the high power requirenent and adopted a vibrational pounding princile. The drill is shown assembled for transport n Figure 1. The motorcycle carries all the quipment and the sample case in the field.

The equipment consists of:

1. vibro-hammer, A; 2. a flexible shaft, , between the motor and the vibro-hammer ith a converter, C, at the motor; 3. motorycle, D; and 4. the auger, E.

The hammer is the most important part of he mechanism for driving the auger into the oil; it is of original design and operates by ammering and vibration. The main working art is the head F, an 0.8 kg steel cylinder ctuated by a crankgear, lying within a hollow ylinder which it moves up and down. There is ir between the head of the hammer and the ase of the cylinder. The compression and xpansion of this air as the cylinder moves up nd down moves the hammer, which is "free-loating" along the vertical in the cylinder cavy. This construction of the working part proects the cylinder and the hammer from wear. n its down stroke the hammer strikes the top f a rod, the lower end of which is inserted in e head of the auger. The hammer head is ctuated by a crankgear driven from the flexile power shaft 1.57 m long which contains a able 10 mm in diameter.

Power is taken from the motor by a converter C mounted on the rear fork of the frame. In operation the motorcycle is mounted on a stand so that the rear wheel can revolve and act as a flywheel. The flexible drive provides 1200-1400 rpm at normal power and the same number of 1 kg blows to the hammer. The work carried out by the hammer is put at 20 kg/m per sec.

An auger of considerable diameter can be driven into the soil very easily. We tested diameters of from 45 to 125 mm. Augers with a diameter of 45 and 55 mm can be driven approximately 100 cm into a fine clay loam of medium compaction in one minute. The construction is such that the whole 100 cm column can be withdrawn and detailed samples taken from it.

The auger E is a cylindrical tube with a 2.5 mm wall and an internal diameter of 40 mm. There are longitudinal grooves for taking soil samples on two sides of the tube, as shown in Figure 1. The tip of the auger has an external diameter of 50 mm, i. e., greater than the external diameter of the tube, so as to decrease the friction of the tube on the sides of the drill hole.

The internal diameter of the cutting edge of the tip is less than the internal diameter of the tube (35 mm). This helps to reduce the friction of the soil column on the tube and to protect the column from vertical compression.

There is a fitting on the upper end of the auger for attaching it to the vibro-hammer or to a rod. A rod on the vibro-hammer is inserted into this fitting on the auger or on a rod. When drilling the vibro-hammer must be inserted into the head of the auger and spring loaded so that the rod will come within reach of the hammer on the up stroke.

In medium and coarse-textured soils the auger can be driven to a depth of 100 cm in one stage. If the soil is so excessively wet

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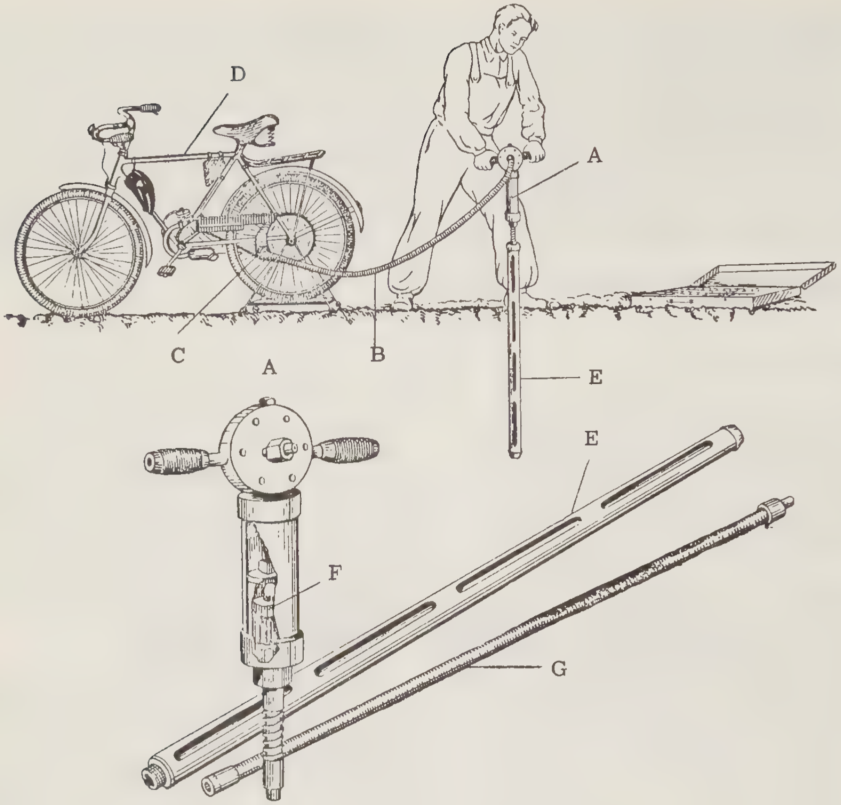
[1] Engineers Stepanov, Khromov and Kharitonov ssisted with the construction and testing of the echanical auger described in this paper.



Mechanical soil auger for taking samples of soil from depths of up to three meters.

that the sample is vertically deformed and compacted and the top of the soil column is below the surface of the soil by the auger, the depth of drilling in one stage must be reduced to 50 cm.

The auger is removed from the soil by the handles. The soil samples are then removed from the tube through the grooves, as are any unwanted remnants of soil.

This method of drilling enables one to take undisturbed samples, by using larger diameter augers. We tested a 125 mm diameter cylinder with an auger bit constructed on the same principles as the first bit.

When taking samples from a depth of more than 1 m, rods (G) with fittings for attachment to the vibro-hammer are connected to the auger

Received March 7, 1959

HE ROLE OF TREES AND SHRUBS IN SOIL PROTECTION ON THE EA COST OF KRASNODAR SUBDISTRICT[1]

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The subtropical regions of Krasnodar sub- strict are an important Soviet center for the roduction of tea, citrus and southern fruits d subtropical crops. The area under these rops is expanded by forest clearance and the ltivation of new lands. Erosional processes ve been extensively developed by the removal woods from mountain slopes. Cleared areas ept under row-cultivated crops are especially fected by erosion. The meliorative role of ountain forests and the development of mea- ures against erosion are therefore of great ractical interest. We studied this question be- veen 1950 and 1954.

Our object was to establish which features of rest soils and forest areas make for resistance erosion, to reveal the changes affecting this esistance which occur when forest soils are owed, and to find cultivation methods which ould improve the resistance to erosion of owed areas. The work was carried out in the lack Sea Experiment Station for Mountain Agri- lture of the All-Union Research Lazarevo strict near Sochi.

Three main methods were used to study ero- onal processes: a) elementary run-off areas x 15 m² for observation during natural precipi- tion, b) sprinkling irrigation of small 2 x 5 ² plots using a rain simulator of the author's esign to provide 1.5-2.0-2.5 mm/min for 15- -60 min. We made 281 sprinklings in all, calculation of erosion from surface scouring.

Run-off and erosion was observed on the rmanent run-off areas during natural pre- pitation in the period from October 8, 1950 to nuary 1, 1953. Run-off and erosional dy- mics for sprinkling irrigation were studied the summer of 1951-1953. The observations ere made on yellow earth podzolized fine clay ams at slopes of 12-20-25° in forests, shrubs, d plowland.

The following main considerations derive from these studies:

Only mountain forests of normal density (0.5 and greater, with thick shrub underbrush and forest litter amounting to 4-7 metric tons/ha possess meliorative properties under Black Sea coast conditions. There is no surface flow and erosion in these forests.

Sparse forests with a density of 0.3 and less which have been cut over and used for grazing and which have poorly developed shrub underbrush and discontinuous forest litter are subject to erosion. There is almost no erosion, despite the formation of considerable run-off, on slopes with sparse forest and cut-over areas with discontinuous forest litter if there is a thick overgrowth of shrubs and grasses.

The main factors related to the meliorative properties of mountain forests are:

1) The density and composition of the forest, which are largely dependent on the location and growth conditions. In the ravines and mountain hollows of the foothill district there is an extremely thin mantle of blanket deposits (0.2-0.7 m) on steep slopes (20-40°) and the soil is very thin (0-0.7 m): growth conditions and the density of the forest are therefore worse here than on the corresponding features in the coastal region.

The forest is less dense and the undergrowth and litter less well developed on sunny slopes, which are drier than the shady slopes: for the same reason vegetation is least developed on the upper third slope than on the middle or lower third slope.

Table 1 shows changes in run-off and erosion in relation to the density of the forest (an average of 3 sprinklings at 2.5 mm/min for 1 hr).

2) The presence of thick undergrowth of shrub, which holds and augments forest litter on the slopes is the best mechanical obstacle

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[1] Presented at the First Delegate Congress of Soil ientists, May, 1958.

Table 1

Run-off and erosion in relation to forest density

Forest density	Gradient, degrees	Surface flow, %	Erosion, kg/ga
Forest, little disturbed by cutting, density 0.5	25	None	
Sparse forest with cut-over shrubs	20	3.0	2.5
Thick shrub	24	14.4	5.0
Shrubs of average density	19	48.8	5.4
Thinned out shrubs	12	65.5	35.5

Table 2

The role of shrubs in the accumulation of forest litter, grams per square meter

Sample site	Upper third of slope without shrubs	Middle of slope with isolated shrubs	Lower third of slope with dense shrubs
Southern slope with oak forest, density 0.3	150	120	470
Southeastern slope with oak forest and an admixture of beech, density 0.4	with dense shrubs 429	192	450

to surface flow and helps to fix the soil with its roots (Table 2).

3) The presence of forest litter. It has been established that a large leaf fall in forests leaves an annual friable, easily decomposed layer of litter 3-6 cm thick on shady and 1-3 cm thick on the middle and lower thirds of sunny slopes, which amounts to 7-10 metric tons/ha of absolutely dry litter on shady and 2.5-4.5 metric tons/ha on sunny slopes. The upper thirds of sunny slopes are devoid of litter.

Forest litter of meliorative significance is only formed and evenly deposited in forests of normal density (0.5 and greater) with thick growth of shrubs. The main species give the most litter: oak — 9120 kg/ha, chestnut — 8910 kg/ha and beech — 7950 kg/ha. The shrubs in the coastal forests give less litter: hazelnut — 3350 kg/ha, hornbeam — 6020 kg/ha, azalea — 770 kg/ha. It has been established that 3-4 cm of litter preserves the soil structure from destruction in the upper layer by raindrops and more than doubles permeability. Owing to its moisture capacity it can hold 2-5 times its own weight of water and completely absorb light precipitation of up to 12 mm.

No surface flow and soil erosion is observed on 20-25° slopes when there is 4-7 metric tons/ ha of forest litter. In the absence of litter, surface flow in a sprinkling experiment was 5%-17% and erosion reached 28.6 kg/ha (Table 3).

Only on Plot No. 7 (with young growth of oak and hornbeam shrub on eroded plowland) did we observe slight run-off within the litter (2.7% The meliorative role of forest litter would be even more evident if areas devoid of litter rathe than artificially cleared plots had been sprinkle

4) Fixing of the soil by roots. We know that roots have a great influence on the erodability of the soil by changing structure, permeability to water, cohesion and other properties. The same plants, under different edaphic and climatic conditions, may however influence the soil unequally. The roots of the indigenous tre and shrubs are almost superficial (S. A. Zakharov, B. B. Polynov, A. I. Voyeykov et al.). As they spread along the base of the underlying rocks (or fine clays), the root systems (especially the dead roots) of the trees create a thick network of drains that can handle a large quanti of the water from precipitation in a short perio

Table 3

The influence of forest litter on erosion[a]

No. Plot	2-4 cm of forest litter				Without litter			
	flow			outwash	flow		erosion	outwash
	surface	intra-soil	erosion		surface	intra-soil		
7	2.7	Not det'd.	1.2	Not det'd.	4.8	Not det'd.	5.5	Not det'd.
8	None	12.7	None	2.9	4.1	21.4	18.7	6.7
9	"	39.2	"	None	9.7	41.8	28.6	8.6

Table 4

Quantity of roots and water intake in forest and old plowed soils

Depth, cm	Chestnut-hornbeam forest, density 0.5	Young beech-hornbeam forest, density 0.8	Braken and azalea thickets, density 0.9	Clover + timothy grass, third year	Old plowland with beard-grass, bottle grass, reed bentgrass, wire grass, thistle and other weeds	
					First	Second
					Plot	
	Absolutely dry roots, kg per 1 m³ of soil					
0—20	5.81	13.02	5.13	4.25	0.6	0.87
20—40	0.96	1.20		Not det'd.	0.17	0.15
0—60	0.32	0.21	1.1	"	0.025	0.03
	Water intake, mm/min.					
0—20	5.52	2.1	1.8	1.42	0.08	0.25
20—40	1.21	0.23	0.49	Not det'd.	0.024	0.17
40—60	1.0	0.13	—	"	0.003	—

It is therefore essential to have at least an approximate idea of the figures for the distribution of roots on afforested and plowed areas and to link these figures with permeability (Tables 4 and 5). Our investigations show that a forest soil profile contains several times more roots than old plowed soils; that the main root mass of trees and shrubs lies in the upper layer of the soil (0-40 cm), which is more permeable to water than the lower, less well drained layers; and that, other conditions being equal, the permeability of soils is directly proportional to the amount of roots they contain.

5) The presence of various types of voids in the soil-root holes, mole holes and also the friable, broken surface with large air spaces created by tree trunks, brushwood, dry branches and litter. Forest soils have a good structure.

Forest vegetation (with shrubs and forest litter) also has a considerable capacity for the accumulation of silt. This is shown by the extensive talus deposits along the lower edges of plowland bordering on forest that are responsible for the typical, mound, elongated ledge microrelief. The following figures for the suspension in the run-off (in grams per liter) illustrate this capacity of forest and grass vegetation under mountain conditions.

Plowland, 15° slope (strong downpour)	12.8
Plowland, run-off for 15 m through forest with shrubs and litter	0.12
Forest path, 15° slope	0.14
Forest path, run-off for 15 m through white clover (growing wild)	0.02
Corn field, 18° slope (strong downpour)	10.4
Corn field, run-off for 8 m through shrub thickets with deep leaf litter (6-7 cm)	1.2
Ridge of plowed watershed (in a current of water, light rain)	0.26
Same, run-off through leaves damming the current of water for a distance of 6 m	0.04

In the mountain forests of the humid subtropics, surface flow is accompanied by intrasoil (5%-70%) flow which causes considerable

Table 5

Dynamics of the water-physical properties of forest soils

Land use	Depth, cm	Particle density	Bulk density	Total porosity	cm^3 of water required to disperse 1 aggregate (after Vilenskiy)	Weight of dry roots, kg/m^2 of soil	Number of earthworms in 50 x 50 x 10 cm of soil	Humus % (after Tyurin)	Water intake, mm/min.	
									in first 2 hrs	steady rate
Forest with litter	0—10	2.49	0.81	67.4	5217.0	7.92	35.0	4.30	181.0	5.5
	20—30	2.61	1.14	56.4	—	0.88	3.0	1.65	—	—
	50-60	2.60	1.16	55.3	—	0.67	None	—	—	—
Grubbed out forest plowed after 1 yr	0—10	2.51	1.07	57.3	330.0	1.6	14.0	Not det'd.	—	1.87
Heavily eroded plowland from under forest	0—10	2.58	1.32	49.0	4.0	1.3	5.0	2.25	0.38	0.28
	10—20	2.65	1.33	49.8	4.3	0.15	2.0	1.60	—	—
	30—40	2.60	1.42	45.5	6.7	—	None	1.02	—	—
Overgrowth with shrubs	0—10	2.49	1.10	56.0	3144.0	5.25	21.0	3.50	4.6	0.92
	20—30	2.55	1.20	53.3	467.0	9.65	3.0	1.45	—	—
	50-60	2.75	1.36	50.5	143.0	0.91	One	0.84	—	—
Slightly eroded plowland from under shrubs	0—10	2.60	1.23	52.7	48.6	1.3	10.0	3.36	0.92	0.33
	20—30	2.64	1.42	46.2	31.7	0.5	4.0	0.65	—	—
	50—60	2.79	1.45	47.8	11.2	0.1	None	0.53	—	—

loss of fine earth and soluble compounds from the soil. The erosional control by mountain forests is due, in the main, to the capacity of the soil to redistribute moisture between surface and intra-soil flow. Study of this question has shown (5) that the magnitude of intra-soil flow and the rapidity with which this flow ceases after the rain slopes increases with increase in the permeability of the soils (Table 8). When highly permeable forest soils were sprinkled for half hour periods, intra-soil flow continued for 30-40 minutes, on old plowed soils that were only slightly permeable intra-soil flow continued for 60-90 minutes. Thus the rate of intra-soil flow is twice as high in the forest as on plowland and the intake rate (infiltration) of precipitation is also considerably higher in the forest than on the field (Table 8). This is the great draining effect of the forest on the soil and soil material that prevents erosion and washing out.

The high erosional control by forest soils is rapidly destroyed when forest areas are converted to agriculture. At each stage in the conversion (felling, grubbing, plowing) the natural structure of the forest soil is further destroyed (loss of litter, roots, structure, air spaces, friable compaction, broken surface and, concurrently, the capacity of the soil to resist erosion) (Table 5).

This is illustrated in Tables 6 and 7 by the run-off, erosion and outwash at different stages in the agricultural development of a yellow earth-podzolized soil.

Surface flow and erosion is markedly increased after the forest and sparse forest with shrubs have been removed. Intra-soil flow is reduced, but the amount of outwash increases. Even so, erosion and outwash remain considerably lower in this case than on old plowed soils. The initial resistance of forest soils to erosion is lowered by 15%-20% when the trees are felled and by 50%-60% when used agriculturally for one year. It has been established in practice that unless measures are taken to prevent erosion, newly grubbed soils completely lose their fertility owing to erosion in 5-6 years.

A study of run-off, erosion and outwashing in relation to the gradient shows that surface and intra-soil flow increase as the slope increases, and is as much as 1.5-2 times for every 5^0 increase in some cases. Thus, for example, the flow (surface — numerator, intra-soil — denominator) for 1 hour sprinkling on wet soil was (in percentages):

Intensity of rain, mm/min	1.5	2.0	2.5
Forest without forest litter, 20^0 slope	$\frac{5}{24.9}$	$\frac{5.3}{27.3}$	$\frac{6.0}{28.1}$
Same, 25^0 slope	$\frac{9}{45.2}$	$\frac{10}{47.7}$	$\frac{17.3}{47.7}$

Table continued on next page

Table 6

Erosional processes at various stages in the agricultural use of forest areas (sprinkling results on wet soil for 1 hour)

Stage of utilization	Legend	Slope 20°			25°		
		Intensity of sprinkling, mm/min					
		1.5	2.0	2.5	1.5	2.0	2.5
Forest with 2-4 cm litter	sf[a]	—	—	—	—	—	—
	if[b]	11.1	22.3	24.2	25.1	23.2	36.2
	erosion[c]	—	—	—	—	—	—
	outwash	—	—	—	—	—	—
Cut-over area	sf	42.6	46.7	51.3	73.5	75.5	86.0
	if	2.8	6.0	6.4	10.5	7.2	10.8
	erosion	174.6	667.0	1071.0	435.0	672.0	1169.0
	outwash	1.3	10.5	9.6	6.4	11.2	21.9
Roots grubbed out and cross ditched to 22-25 cm	sf	—	—	—	—	—	—
	if	25.0	25.2	24.4	63.9	48.5	38.0
	erosion	—	—	—	—	—	—
	outwash	51.9	77.3	67.3	50.1	48.0	52.1
					Plowland from under forest after a year		
Deep plowing (50 cm) after a year	sf	31.8	37.5	38.0	10.0	16.4	29.3
	if	6.2	8.2	6.4	31.9	41.3	31.0
	erosion	382.0	1200.0	1669.0	367.2	1940.0	4089.0
	outwash	46.8	13.6	33.0	91.0	36.3	84.0
The same soil compacted after 15 years of cultivation	sf	75.1	81.0	63.0			
	if	13.0	13.9	23.1			
	erosion	311.6	985.0	15520.0			
	outwash	11.3	10.4	86.0			

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[a] sf — Surface flow as a percentage of precipitation

[b] if — intra-soil flow as a percentage of precipitation

[c] Erosion and outwash are given in kg/ha

ut-over area, 20° slope $\frac{42.6}{2.8}$ $\frac{46.7}{6.0}$ $\frac{51.3}{6.4}$

ame, 25° slope $\frac{73.5}{10.5}$ $\frac{75.5}{7.2}$ $\frac{86.0}{10.8}$

Such a clear relationship of the increase in un-off on the increase in the gradient is, how-ver, only seen on soils of equal permeability. hen studying this relationship under natural nditions it is extremely difficult to select reas in which all factors except the gradient re identical. Therefore, when sprinkling other lots of various gradient (fallow, shrubs) we did ot find a direct relationship (Table 7 and 8). is, moreover, clear from Table 8 that run-f and erosion are far more affected by vegeta-on and the soil properties (permeability) than the gradient of the area. In this sense it can said that under mountainous conditions the fluence of slope is often cancelled by the dif-rent structure of the soil and soil material d by the condition of the surface.

Surface and intra-soil flow increase as the tensity of the rain rises, except on newly owed areas, where intra-soil flow declines owing to the silting of non-capillary channels. Erosion of the soil is also increased as the intensity of the rain increases, but the rise is equal in different places. On compacted old plowed soils and on cut-over areas intensive rain causes considerably more erosion than on areas of forest and shrubs. The intensity of the rain has a less marked effect on outwash. There is a general tendency for outwashing to increase on virgin soils but it declines as the intensity of the rain increases on freshly plowed soils.

We have established by sprinkling that surface flow increases rapidly as the intensity of the rain rises. This is especially noticeable on old plowed fine clay loams, where the water-conducting channels become clogged by outwashings and by the swelling of the soil as wetness increases. Intra-soil flow also increases with the duration of the rain, especially on highly permeable (forest) soils. Run-off remains stable for declines on old plowed fine clay loams.

Erosion and outwashing increase as the duration of the rain is prolonged: not indefinitely

Table 7

Erosional processes at various stages in the agricultural use of shrubs and grasses (sprinkling results on wet soil for 1 hour)

Land use	Legend[a]	Slope 12°			19°			2 °		
		Intensity of rain, mm/min.								
		1.5	2.0	2.5	1.5	2.0	2.5	1.5	2.0	2.5
Shrubs and grasses	sf	46.9	62.2	64.5	41.2	45.4	48.8	11.3	14.1	16.3
	if	12.4	9.1	12.0	42.8	42.0	44.3	58.4	61.8	62.0
	erosion	31.3	50.2	53.5	—	7.1	8.6	6.1	10.2	12.0
	outwash	9.6	7.7	12.6	30.8	5.8	16.6	30.4	46.3	26.1
Shrubs and grasses removed	sf	73.0	73.7	73.0	82.2	86.1	88.0	55.2	61.5	70.3
	if	3.0	2.5	2.6	4.8	4.7	4.5	31.4	32.8	28.4
	erosion	144.6	125.5	439.3	343.3	560.0	600.0	130.0	172.0	190.0
	outwash	3.2	3.4	4.1	4.7	7.5	5.4	58.3	112.8	115.3
Grubbed, roots removed and deep plowed (22-25 cm)	sf	19.6	24.3	30.7	2.3	3.4	5.2	—	—	—
	if	49.0	41.6	35.2	64.2	50.0	48.6	71.0	57.6	58.0
	erosion	25.4	31.8	30.4	4.9	4.3	3.3	—	-	—
	outwash	25.9	52.2	41.8	130.0	92.8	54.0	81.3	106.3	220.5
Old plowed compacted soil	sf	53.2	60.1	68.4	62.5	73.0	82.4	62.3	70.0	75.2
	if	21.2	21.3	26.5	5.8	7.1	11.3	None	—	—
	erosion	4697.0	1100.0	2682.0	1050.0	1420.0	3030.0	1542.0	1771.6	5884.7
	outwash	124.0	115.0	128.0	49.7	76.0	130.0	—	—	—

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[a] See Table 6 for explanation.

[b] Subsoil layer — detritus.

Table 8

The effect of slope on run-off and erosion (sprinkling on wet soil for 30 min at 2.5 mm/min)

Land use	Degree slope	Water intake, mm/min	Flow, %		Erosion	Outwash
			surface	intra-soil	kg/ha	
Fallow	12	1.23	61.5	16.5	1000.0	60.0
Fallow	20	0.28	88.0	5.4	980.0	54.3
Fallow	25	0.33	74.6	—	1795.5	—
Shrubs	12	0.35	73.6[a]	11.7	30.0	8.8
Shrubs	19	0.92	48.6	47.2	None	22.0
Shrubs	24	1.43	17.1	71.3	6.0	38.3
Forest with litter	20	5.52	None	17.4	None	
Forest without litter	20	—	5.0	24.2	19.0	3.6
Forest with litter	25	5.52	None	54.0	None	
Forest without litter	25	—	8.1	37.7	27.8	4.9

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[a] Rain intensity, 2.0 mm/min.

however, but until the least cohering soil particles have been eroded or washed out, after which the concentration of solid flow declines even when the volume of liquid flow increases.

We found that the ratio of total erosion (from all sprinklings) in the forest without litter to erosion on the cut-over forest and on old plowland was as 1:21:159°, on plots overgrown with hrubs in ratio to cut-over shrubs and to old lowland as 1:52:246.

We found from observations on permanent lots that winter rains exceeding 0.5 mm/min ive rise to 4 times more flow on old plowland nd 8 times more on forest and shrub plots than oes summer rain. Therefore, and also beause there is more precipitation in the winter, oil erosion is considerably higher in the winter. otal erosion is 11 times less on sparse forest nd 38 times less on thick bush scrub than on a orn field. The minimum amounts of precipitaion that cause run-off when it falls at 2.5 mm/min on 20-25° slopes are very great in the forest and on freshly plowed forest soils (more han 300 mm). On cut-over areas overgrown vith shrubs and grasses these amounts are exceedingly small (less than 20 mm), while on compacted plowland run-off forms almost simultaneously with rainfall.

In the course of our investigation we also ested various measures controlling erosion, ncluding deep plowing (25-27 cm), planting egumes as green manure, planting perennial rasses and mulching. Deep plowing greatly reduces surface flow and erosoin by increasing vater intake (Table 6 and 7). Deep plowing is, owever, only effective against erosion if the lownward current of water is isolated from bove and only lasts for 3-4 months after plowing on fine clay loams and 1 month on coarse soils. The planting of perennial rye and lupine on 12-20° slopes reduces surface flow by 7%-5% and practically stops erosion. Under Black Sea coast conditions the planting of perennial grasses on old cultivated eroded soils at the close of the first year of vegetation can completely stop erosion.

Mulching with ferns (a 10 cm layer) between he rows of young tea and citrus plants, which s recommended for subtropical crops, coniderably reduces surface flow, almost halts rosion, conserves soil moisture from evaporaion and protects the upper layer from compacion and loss of structure (Table 9).

As a result of our studies we have subdivided he mountain forests of the coastal region into hree groups by meliorative properties:

1. Forests that retain their meliorative roperties to a considerable degree.

2. Forests that have lost the greater part of heir meliorative properties.

3. Forests with intermediate meliorative roperties.

A study of geomorphological conditions and rosion shows that if erosion is to be prevented ere 50% of the area must be retained as forest (ncluding wooded strips) and 50% put to agricultural use.

Great care and planning must be used in converting forest land to agricultural use. Slopes must not be totally cleared, but strips of woodland and cropping strips must be left on watersheds, steep slopes and the sides and bottom of the hydrographic network. Water absorbing wooded strips 8-12 m wide must be left at least every 50 m on the slopes. When clearing sparse forest and shrubs, new water absorbing strips must be planted on the area before clearance takes place.

Forest and cropping strips, and blocks of forest on watersheds, steep slopes and the banks (sides of the hydrographic network must have a high capacity to absorb water and withstand erosion. Therefore, to improve the meliorative role of mountain forests all plantings must be of the three story type with unbroken thick shrubs. Since the majority of the forests (disturbed by cutting and cattle grazing) are now of little use for melioration and are also low in yield, they must be gradually converted to more productive, more effective plantations of the spa region type. The conditions of forest growth on different areas must be studied to establish the combinations that will grow successfully.

The best conditions for forest growth are on slopes (N, N-W, N-E) with thicker blanket deposits and soils; the worst on sunny slopes with drier, poorer soils. The following combinations are suggested as an example for strips, belts and blocks of forest.

On sunny slopes and watersheds with underdeveloped or eroded stoney soils: first story — red oak, maritime pine, cypress; second story — sweet cherry, dogwood, pear, checker tree, ailanthus; third story — hazel, sea buck thorn, tanner's sumac, plum tree, box tree.

On shady slopes and deep watershed saddles: first story — sweet chestnut, beech, himalayan cedar, Cryptomeria japonica, sequoia; second story — sycamore, laurel cherry, laurel, apple, pear.

On loose slopes and water-logged areas: first story — eucalyptus; second story — fig, mulberry, osage orange; third story — hazel, bamboo, Amorpha.

In the valleys of rivers and streams: walnut, honey locust, eucalyptus, hazel, plum, Amorpha.

Since erosion processes are very intensive in the winter, plowed lands must not be left for the winter without planting with winter legumes for green manure and mulch. This is of extremely great importance owing to shortage of fertilizers and transportation difficulties in the mountains. Summer legumes for green manure

Table 9

The effect of agricultural practices on run-off in percentages and on erosion in kg/ha (sprinkling results at 1.5 mm/min for 15, 30 and 60 min)

Practices	Minutes					
	15		30		60	
	run-off	erosion	run-off	erosion	run-off	erosion
Compacted fallow, 25° slope	62.0	1542.0	63.2	7267.5	87.0	12927.0
Same, plowed to 25 cm	13.1	22.4	11.2	47.5	12.8	72.9
Perennial rye at the boot stage, wide row planting, 12° slope	37.1	14.6	37.8	22.5	43.3	187.7
Mulched[a] with a 10 cm layer of fern, 12° slope	39.7	15.3	42.0	24.8	46.5	45.5
Compacted fallow, 12° slope (control)	44.2	673.0	47.2	1089.0	53.2	4697.0
Lupine, 20° slope	None		5.0	5.6	1.8[b]	2.0
Control, 20° slope	—	—	31.0	1200.0	23.1	2417.4

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[a] The wet soil was mulched.

[b] Sprinkling dry soil.

should also be planted.

Mineral and organic fertilizers should be applied in the autumn when leaching is most intensive, since considerable quantities of nutrients are removed from the soil by intrasoil flow.

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BIBLIOGRAPHY

1. AMBOKADZE, V. A. 1950. Soil erosion on the northeastern slopes of the Trialeti range. Tr. In-ta pochvov, AN GruzSSR, Vol. 3.

2. ARMAND, D. L. 1956. Distribution of forest strips and a discussion of soil run-off. Izvestiya, Ser. Akademiya Nauk SSSR, Geogr., No. 2.

3. BRAUDE, I. D. 1950. Controlling erosion in the mountains. Goslesbumizdat, Moscow.

4. BURYKIN, A. M. 1958. Role of forest in preventing erosion on the mountain slopes of the Caucasian Black Sea coast. Tr. Tadzh. SKhI, Vol. 1.

5. BURYKIN, A. M. 1957. Intra-soil flow in mountain conditions in the humid subtropics. Pochvovedeniye, No. 12.

6. VOZNESENSKIY, A. S. 1940. The resistance of the main Transcaucasian soils to erosion. Zak. NIIVKh, Tbilisi.

7. VYSOTSKIY, G. N. 1950. The theory of the effect of forest in altering its own and surrounding growth conditions. Goslesbumizdat.

8. GAGOSHIDZE, M. S. 1949. The general fe tures of mountain torrents, erosion water and centers of the formation of erosion waters and aspects of their formation. In: Proceedings of the Jubilee Session commemorating the 100th anniversary of the birth of V. V. Dokuchayev. Izd. AN SSSR, Moscow-Leningrad.

9. DARASELIYA, M. K. 1948. Soil erosion and measures against erosion on subtropical soils. Byul. In-ta chaya i subtrop. kul'tur, No. 1.

10. ZONN, S. V. 1950. Mountain-forest soils of the northwestern Caucasus. Izd. AN SSSR.

11. KOBEZSKIY, I. D. 1941. Role of forest and grass in controlling erosion. Lesno Khozyaystvo, No. 6.

12. KOZMENKO, A. S. 1954. The principles o erosion control practices. Sel'khosgiz.

13. KOCHERGA, F. K. 1953. Mountain district melioration in Soviet Central Asia and Southern Kazakhstan. Goslesbumizda

KUZNETSOV, N. I. 1938. The protective role of the forest in the mountains of the western Caucasus. Lesnoye khozyaystvo, No. 5.

LOBZHANIDZE, G. A. 1955. Study of erosion in the cinnamon-brown forest soil zone (oak belt) of eastern Georgia. Tr. Gruz. SKhI, Vol. 42.

MAKHATADZE, L. B. 1949. Surface erosion in the forest. Lesnoye khozyaystvo, No. 5.

MIKHAYLOV, D. YA. 1950. Soil erosion and erosion control measures in the mountain forest zone of the Tyan'-Shan'. Kirgiz. fil. AN SSSR, No. 3. Tr. In-ta pochvov., Fasc. 3.

RAKHTEYENKO, I. N. 1952. The root systems of trees and shrubs. Goslesbumizdat, Moscow-Leningrad.

19. ROSHCHIN, N. I. 1938. The influence of forest litter on the prevention of soil erosion. In the collection: Controlling soil erosion. Izd. AN SSSR.

20. SOBOLEV, S. S. 1958. Controlling soil erosion. Izd. Znaniye, Moscow.

21. Collection: Controlling soil erosion in the USSR, Sel'khozigiz, 1958.

22. SUS, N. I. 1937. Forests in relation to water retention and regulation and soil protection. VASKhNIL.

23. KHARITONOV, G. A. 1939. Role of the forest in erosion control in relation to protection of rivers from silting. Tr. VNILKh, No. 8.

DETERMINATION OF TOTAL SOIL ACIDITY

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Kappen's method, in which soil is treated with 1.0 N sodium or calcium acetate in a soil: acetate solution ratio of 1:25, is used to determine the hydrolytic acidity of soils. The extent of the hydrolytic acidity is estimated from the amount of acetic acid formed in an equilibrium solution which has a slightly acid (pH 6.4-6.8) reaction, or more rarely a neutral and most rarely a weakly alkaline reaction (pH 7.2).

Kappen introduced the coefficients 1.75 for sodium and 1.5 for calcium acetate for calculating the hydrolytic acidity in meq, since the reaction for the substitution of the adsorbed H-ion by the acetate cations is not completed.

Although far from satisfactory, the Kappen method is widely used in laboratories. Its drawbacks include: 1) an excessively wide soil: acetate solution ratio, which calls for a great deal of the reagent; 2) the need for conditional coefficients since the substitution reaction is incomplete; 3) unrealistic high results (Table 2, Nos. 28, 29, 30, 31) in gley soils and soils rich in organic matter if ferrous oxides are present; 4) "acidities" of the order of 0.3-0.8 meq (Table 2, Nos. 34, 35, 36) even in carbonate soils; and 5) a colored filtrate from soils rich in organic matter, which complicates determination of the end of the titration and leads to exaggerated results.

To overcome these drawbacks, the author has devised a method for determining the hydrolytic, or more accurately, the total acidity of the soil by the use of smaller quantities of more readily available reagents. The principle of the method is that acid soil is neutralized by excess sodium bicarbonate ($NaHCO_3$), which neutralizes the most acid soils (200 ml of 0.01 N bicarbonate of soda to 10 g of soil, which is the equivalent of 30 metric tons of $CaCO_3$ $_1$in the plowed layer of a hectare of limed soil).[1] To speed the reaction and ensure complete substitution of the Na-ions for the exchangeable cations responsible for soil acidity, the 0.01 N $NaHCO_3$ is prepared in 1.0 N NaCl (solution A). When the soil is saturated with sodium the amount of sodium carbonate in the solution decreases but the sodium chloride level remains constant owing to replacement by sdoium chloride formed on neutralization of hydrochloric acid by sodium carbonate (see the reaction equation). The resultant carbonic acid (H_2CO_3) does not affect completion of the reaction and titration by acid in the presence of methyl orange. The acid soil + solution A reaction is:

1) soil H_2 + $NaHCO_3$(n) + NaCl(m) = soil Na_2 + H_2CO_3 + $NaHCO_3$(n-1) + HCl + NaCl(m-1).

2) $NaHCO_3$(n-1) + HCl = $NaHCO_3$(n-2) + NaC + H_2CO_3.

Solution A is prepared by weighing out 58.5 g NaCl on a chemical balance and 0.84 g NaHC on an analytical balance and dissolving these reagents in exactly 1 liter of distilled water. When solution A reacts with the acid soil its initial pH (7.6-7.8) is lowered to 7.2-7.5 and this facilitates saturation of the soil by the cation in a weakly alkaline medium.

The amount of sodium bicarbonate used is calculated by comparing the results of titrating the filtrate with 0.05 N H_2SO_4 with the data for a blank titration of the initial solution A.

Procedure for determining total soil acidity. The soil is air-dried and passed through a 1 m mesh sieve and weighed out on a chemical bala (10 g for mineral and 5 g for peaty soil). The soil sample is placed in a flask and exactly 20 ml of reagent A are added. The contents of th flask are shaken 5-6 times in an hour and left to stand for 15-20 hours after which they are again shaken and passed through a folded filter Two 50 ml portions of the filtrate are then pipetted and titrated with 0.05 N H_2SO_4 in the presence of methyl orange until a light rose orange shade develops.

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[1] The sample should be reduced to 5 g for peaty, more acid soils.

Table 1

Conversion factors for calculating metric tons of $CaCO_3$ per ha

Soil	Weight of plowed layer, metric tons/ha	Factor
Podzolized and sod-podzolized	3000	1.5
Grey forest (podzolized)	2600	1.3
Leached and podzolized chernozems	2400	1.2
Clay-bog	2000	1.0
Peat-bog	1000	0.5
Peat	600	0.3

The acidity of the soil in 100 g of soil is ven in meq by the following formula:

$$\frac{4(a-b)\,N\cdot 100,}{H}$$

ere a is the amount of acid of N normality ed in the blank titration of 50 ml of sodium arbonate (reagent A); b is the amount of d of the same strength used in titrating 50 of the filtrate; N is the normality of the d; 4 is the multiplier that converts to the al volume of the filtrate (200 ml); H is the ight of the sample in grams; 100 is the mul-lier for calculation of the acidity in meq per) g of soil.

If the sodium bicarbonate solution is exactly 1 N and the acid is 0.05 N and if the soil nple is exactly 10 g, the shortened formula — 2b = meq per 100 g of soil may be used, ere b is the amount of acid used in titrating ml of the filtrate.

The amount of $CaCO_3$ in metric tons per ha lime the soil is calculated by multiplying the q for the acidity of 100 g of soil by the con-sion factors given in Table 1, which allow the weight of the plowing layer (0-20 cm) a hectare.

When using materials with a low $CaCO_3$ con-t for liming (limestones, chalk, marl, lime es, loess, etc.), the carbonate percentages st be calculated and the figures corrected.

Determination of soil acidity by the Kappen l Godlin methods is compared in Table 2 m figures obtained by analysis in various oratories. The table shows that the two s of results are in good agreement (with the eption of No. 2) if calcium acetate were d in the Kappen method (Nos. 1, 3-9).

When sodium acetate was used in the Kappen method, some results agreed and others showed considerable divergences, especially on gley peaty-podzolized soils and on peaty-meadow and peaty soils with high humus content (Nos. 13, 28, 29, 30, 31). Divergences in these soils may be due to the presence of ferrous oxides and the increased organic content. These would undoubtedly give rise to additional amounts of the alkali used by hydrolysis of the acetates on the formation of ferrous hydroxides and to its physical adsorption by the organic matter in the soil.

An "acidity" of the order of 0.26-0.85 meq per 100 g of soil revealed by the reaction of the acetate solution on carbonate soils with a pH (saline) of 6.9-7.6 also confirms the pypothesis that there is physical adsorption of the alkali (NaOH) by soil colloids and does not support the use of acetates to determine hydrolytic activity in non carbonate soils. No "acidity" was detected by the author's method in carbonate soils (Table 2, Nos. 34-36).

Conclusions

The author's new method for determining total soil acidity has a number of advantages over the widely used Kappen method for the determination of hydrolytic acidity:

a) the reagents are more available than acetates and only very small quantities of sodium bicarbonate are used:

b) the reaction between the soil and the bi-

Table 2

Comparison of the two methods of determining soil acidity

Number	Soil and place	Depth cm	Acidity, meq: Kappen's method reagent acetate Na	Acidity, meq: Kappen's method reagent acetate Ca	Acidity, meq: Godlin's method	Analysts
1	Leached chernozem, Krasnodar region	0—20	4.2	4.46	4.5	T. N. Antonova
2	Podzolized chernozem, Kharkov region	0—20	—	3.02	3.4	"
3	Leached chernozem, Nosovka	0—20	4.1	3.2	3.2	"
4	Medium leached chernozem, Drabovo	0—20	2.6	2.9	3.1	"
5	Dark-grey podzolized, Chartoriya	0—20	1.4	1.4	1.5	"
6	Grey podzolized, Chartoriya	0—20	1.3	1.7	1.7	"
7	Peaty-medium podzolized, Goloseyevo	0—20	2.8	3.1	3.2	"
8	Peaty-medium podzolized, Gostomel'	0—20	2.2	2.4	2.6	"
9	Peaty-medium podzolized, Bucha	0—20	2.4	2.8	2.8	"
10	Peaty-podzolized, underlain by sand	0—20	2.6	—	2.8	Ye. F. Totskaya
11	Sod-weakly podzolized	0—20	2.1	—	2.0	"
12	Sod	0—20	3.6	—	4.0	"
13	Sod-meadow	0—20	11.7	—	10.0	"
14	Dark-grey podzolized	0—20	1.65	—	1.60	"
15	Low humus chernozem	0—20	2.90	—	3.20	"
16	Dark-grey podzolized	0—20	2.8	—	2.8	"
17	Same	0–20	1.8	—	2.0	"
18	Dark-grey podzolized coarse clay loam	0—20	1.53	—	1.60	From the data of I. L. Abarbarchuk
19	Grey podzolized sandy loam	0—20	2.43	—	2.40	"
20	Same	0—20	2.88	—	2.70	"
21	Sod, weakly podzolized clay-sand	0—20	2.07	—	1.86	"
22	Grey podzolized coarse clay loam	0—20	2.97	—	2.93	From the data of I. L. Abarbarchuk
23	Thin sod	0—20	3.82	—	3.60	G. A. Linnikova (UNDISOZ)
24	Sod medium podzolized	17—30	1.87	—	1.73	"
25	Meadow podzolized	0–20	2.04	—	2.10	"
26	Sod medium podzolized	5—15	2.38	—	2.10	" "
27	Sod weakly podzolized	0—19	2.21	—	2.10	"
28	Sod gley	5—15	2.63	—	1.60	"
29	Same	0—17	7.91	—	5.26	"
30	Clay-bog	0—20	11.82	—	6.26	"
31	Low moor peat	0—56	13.9	—	9.40	"
32	Sod weakly podzolized, Mostishche, Byshevsk district, Kiev region	0—10	1.68	—	1.5	
		10—17	1.79	—	1.6	A. I. Radetskaya
		22—28	0.92	—	0.9	"
		0—30	1.72	—	1.5	"

Table 2 Continuation

Number	Soil and place	Depth cm	Acidity, meq			Analysts
			Kappen's method reagent acetate		Godlin's method	
			Na	Ca		
33	Sod weakly podzolized, Pluzhnoye district	25—35	2.25	—	2.8	A. I. Radetskaya
		10—20	2.21	–	2.5	"
		0—10	4.42	—	4.0	"
		0—20	2.21	—	2.7	"
34	Sod-meadow soil, "Khleborob" kolkhoz, Smela district	0—5	0.85	—	0.00	T. N. Antonova
		5—10	0.26	—	0.00	"
		10—20	0.26	—	0.00	"
35	Chernozem, "Peremoga" kolkhoz, Popel'nya district	0—20	0.48	—	0.00	"
36	Sod-meadow soil, Bobrovitsa, Kiev region	0—20	0.35	—	0.00	"

rbonate solution takes place and finishes a weakly alkaline medium. Acidity can erefore be calculated from the titration sults without having recourse to Kappen's nditional coefficients.

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BIBLIOGRAPHY

1. GODLIN, M. M. 1934. The determination of hydrolytic acidity. A guide to procedure. VIUAA.
2. GODLIN, M. M. 1937. Determining liming requirements of soils. Pochvovedeniye, No. 2.

AN ABBREVIATED SCHEME FOR THE AGGREGATE ANALYSIS OF SOIL

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A method for determining the aggregate composition of soil, as proposed by Savvinov, is labor-consuming. Moreover, the author does not make any recommendations on how to use the results obtained. He only points out that in structured chernozems there are 50%-60% water-stable aggregates >1 mm and in old plowed soils 4%-10%. With such indeterminacy sieving a sample of soil through an entire nest of sieves is not actually necessary. Therefore, we have worked out an abbreviated scheme for the aggregate analysis of soil, which is a modification of Savvinov's method. Essentially, it consists as follows:

Dry sieving is done on three sieves (0.25; 1.3 and 10 mm openings); a wet sieve analysis on two sieves (0.25 and 1 mm openings). In connection with the fact that weight of soil on one sieve doubles the load the amount of soil during dry sieve analysis is transferred to the upper sieve not in 100-200 gram portions as described by Savvinov, but in 50-100 gram portions, depending upon moisture (we may take 100 grams of dry soil and not more than 50 grams of "mellow" soil for one sieving).

Shaking both sieves ten times is sufficiently adequate in wet sieve analysis in order that the particles < 1 mm in diameter will fall through onto the lower sieve. However, after removing the upper sieve the lower sieve should be shaken ten additional times.

There is approximately half as much work involved in conducting one analysis; the results of parallel analyses (See Table 1) differ very little. As we see from the table, the variation may be in one and the same direction.

By obtaining a large number of figures in analyzing the aggregate composition according to Savvinov, we find ourselves interesting actually only in the result. In the abbreviated scheme analysis we have twice fewer figures, which facilitates comparison. With the wet sieve analysis, for example, we get only two figures: aggregates >1 mm and the total amou of aggregates >0.25 mm which, in essence, does not characterize the structured state of the soil. Actually, we have taken for analysis two soil samples — one structureless, the other structured. The analysis which showed that there were almost five times fewer aggregates >1 mm in diameter in structureless soil than in structured soil confirmed this. However, the total amount of aggregates >0.25 mn in diameter turned out to be almost the same.

Noting that in structured and structureless soil the amount of aggregates >1 mm in diameter strongly differs, Savvinov does not refer to aggregates 0.25 to 1 mm in diameter, which represent the secondary indicator of the effect of agricultural methods (for example, sowing of perennial grasses) on the structured state of the soil. Our analyses have also confirmed this. The abbreviated scheme for the aggregate analysis of soil may be recommende for mass analyses in production laboratories.

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See Table 1 on next page

Table 1

Comparative results of aggregate analysis of soil

After Savvinov			Modification of Savvinov's Method		
Fraction, mm	Soil		Fraction, mm	Structured	Structureless
	Structured	Structureless			
Dry sieve analysis					
>10	33.5	66.4	>10	22.8	57.1
5—10	14.6	7.2	1—10	38.8	27.3
3—5	13.4	4.1	0.25—1	34.2	13.2
2—3	15.3	3.1	<0.25	4.2	2.4
			Total	100	100
1—2	12.2	3.2			
0.5—1	6.4	7.1			
0.25—0.5	3.3	4.8			
<0.25	1.3	4.1			
Total	100	100			
Wet sieve analysis					
>3	30.04	2.50	>1	42.48	8.66
2—3	3.24	2.06	0.25—1	13.34	46.40
			Total	55.82	55.06
1—2	4.42	4.42			
0.5—1	10.30	26.60			
0.25—0.5	6.64	20.88			
Total	54.64	56.46			

CHRONICLE

REPORT OF THE ACTIVITIES OF THE SOIL SCIENCE UNIT AT THE SECOND ALL-UNION SCIENTIFIC CONFERENCE OF BIOLOGY STUDENTS IN MOSCOW

R. M. ALEKSAKHIN

The Second All-Union Scientific Conference of Biology Students, held under the auspices of Moscow State University and the Timiryazev Agricultural Academy, met from March 10th through March 14th, 1959 at the Biology-Soil Department of Moscow State University. The conference was dedicated to the memory of Jean Lamarck and Charles Darwin as the modern scientific world of 1959 celebrated the 150th Anniversary of the publication of "The Philosophy of Zoology" and the 100th Anniversary of "The Origin of the Species."

The scientific endeavors of Charles Darwin, who was highly valued by classicists of Marxism and Leninism, had a profound influence on the development of all biological sciences, including even soil science. In the middle and second half of the nineteenth century, when the geological trend of soil study developed and became dominant in Western Europe, the brilliant naturalist Darwin came forth with clear and interesting biological concepts on soil formation. His research on the role of earthworms in soil formation is still important today and has been recognized as classical.

Soil science students of eight cities in our nation participated in the work of the conference. These cities were: Moscow, Leningrad, Alma-Ata, Tashkent, Stalingrad, Tomsk, Bryansk and Yoshkar-Ola. For the first time at this second All-Union Conference young soil scientists of the various cities in the USSR had an opportunity to become acquainted with and share the results of their scientific research.

Work of the soil science section was carried out in six sections of the Conference. Fifteen reports were heard and discussed in the soil science section during two days of meetings. Several reports on soil science problems were heard at the microbiology and agronomy sessions.

The reports dealt with problems of site quality and chemical appraisal of soils, large-scale mapping, use of fertilizer, virgin-land cultivation, study of the dynamics of soil-forming processes, genesis and reclamation of salinized soils, forest soil science and other problems. Most problems dealt with by the speakers were closely associated with agricultural and forestry practices.

The members of the conference listened intently to a report by I. I. Ivanov (Stalingrad) "Soils as the Mirror of the Landscape," where he analyzed the role of soil science in studying the dynamics of landscapes. Soils are the most sensitive indicator of a change in vegetation and relief. The theoretical views expressed were illustrated by the study of the interrelationship between soil and the landscape elements of the Volgo-Akhtubinskaya flood plain.

The report of R. Aleksakhin (Moscow), gives results of two years' study of a small biological cycle of elements in the aspen and basswood stands of the Voronezhskiy State National Forest. Based on a study of the physicochemical, microbiological and faunal properties of soils and litter, a conclusion was reached regarding the favorable effect of the basswood upon the forest properties of soil under a canopy of aspen; the effectiveness of improvement cutting so as to transform a low-productive aspen stand into basswood stand was substantiated. Given is certain new data on the study of the role of the forest in the energy balance of soil formation. Forests on the earth annually synthesize 1.54×10^{10} metric tons of organic C compounds which amounts to 75% of total C synthesized by the total vegetation of the biosphere. And 1.45×10^{20} energy calories a year (approximately 1/3,000th of the total sun's energy falling on the surface of the earth) is transformed onto the soil by dead organic matter of forest formation.

The report of Kh. Abdukadyrov (Tashkent) was devoted to the problem of reclaiming the salinized soils of the Golodnaya Steppe. A high salt content in the soil, an extreme comlex relief and ground water near the surface haracterized by severe salinization, were obtacles to successful cultivation of cotton and ther agricultural crops in this district. Based n the example of the Sovkhoz "Friendship," ne speaker discussed a system of measures imed at reclaiming lands: reclamation had to egin from higher areas, a network of temorary drainage ditches, 0.75-1.0 m deep and 5-100 m apart had to be used, irrigation usng fresh water had to be mechanized, and oils under rice cultivation were reclaimed.

The report of G. Bondarenko (Moscow) disussed the problems of studying the salinizaion of soils of the Yavanskaya Valley (Tadhik SSR) and Karabakhskaya Steppe (Azeraydzhan SSR). From a study of the changes y stages in the chemistry of soils and ground ater it was determined that the roots of elm Ulmus densa) play an active role in the dealinization of the soil layer. The surface art of plants participates in the salinization f only the surface horizon of soils (0-5 cm rusts).

It was determined from experiments conucted by the speaker that solonchaks and trongly salinized soils of the Karabakhskaya teppe may be transformed into zonal group oils (chestnut soils) after one or two years f leaching under drainage conditions.

Methodology of A. Gorb (Moscow) on the etermination of adsorbed sodium in soils by ne Na glass electrode was received with inerest. An original method of determination as proposed: 5 grams of soil are treated ith five successive portions of 0.5 N $NH_4)_2CO_3$ up to 250 ml. The filtrate is preipitated until dry and the dry residue treated ith 50 ml in $BaCl_2$. The filtrate is transerred to a measuring beaker and the EMF of ne glass-calomel is measured. The concenation of Na ions in a solution corresponding the given EMF is taken from a calibrated traight line.

Among the reports (M. Bel'gibayev, A. spanov [Alma-Ata], R. Linnik [Moscow]), presented data on large-scale mapping of eparate Kolkhozes and Sovkhozes with concrete agronomic and scientific agricultural recommendations for increasing the fertility of the soils studied.

The report of I. Korshunov (Moscow) offers data on the study of the effect of small doses of radioactive elements on the growth and development of legumes. From field and greenhouse experiments it was determined that introducing small doses of Ra has a positive effect on increasing the yields of kidney beans, peas, and lupine and increasing the number of small nodules on the roots of these plants.

Among the reports heard at the conference were those of N. Kalinin (Leningrad) on the effect of Cu micro-fertilizers on peats; M. Stroganova (Moscow) on sod-podzolic soils of the Krasnoyarskiy Kray; V. Golov (Yoshkar-Ola) on the biological activity of sod-podzolic soils under certain forest plantations; A. Zhamankulov (Alma-Ata) on vertical zonality of vegetation and soils of Rudniy Altay; M. Dronzhevskiy (Bryansk) on the effect of the extent of soil erosion on crop yields; G. Terent'yeva (Tomsk) on water-physical properties of dark chestnut soils of the Tsentral'no-Kulundinskaya Depression; A. Dayerbayev (Alma-Ata) on the ground water and moisture regime of bamboo meadow and bog soils of the Aksayskiy massif, Alma-Atinskaya Oblast'; and V. Novoselov (Moscow) on the ecologic-geographic distribution of microorganisms in soils.

During the conference excursions were organized for the soil science students by faculties of the Soil Branch of the Biology-Soil Department, Moscow State University, to visit the V.R. Vil'yams Soil-Agronomy Museum, the Timiryazev Agricultural Academy and the Museum of Geography, Moscow State University. The conference was well organized; the report abstracts were published before the beginning of the conference. The conference contributed to strengthening and broadening contacts among young soil scientists of the nation and to coordinating teamwork.

A decision was made to hold the next All-Union Conference of Biology Students in 1961 in Kiev.

FEDOR YEFREMOVICH KOLYASEV

By Colleagues of the Scientific Research Institute for Agricultural Physics and of the Lenin All-Union Agricultural Academy

On December 17th, 1958, senior colleague of the Scientific Research Institute for Agricultural, director of the Soil Physics Laboratory, Doctor of Agricultural Sciences, Professor Fedor Yefremovich Kolyasev died suddenly at the age of 61.

The collective of the Agricultural Physics Institute working on application of the achievements of physics to agriculture has lost in the person of Fedor Yefremovich Kolyasev an active creator of a new science—agronomic physics.

From the very first days of his agronomic activity, Fedor Yefremovich Kolyasev strove to understand the physical laws which govern the processes in soil and in plants and make agronomy a physical science. One of the leaders of Russian agronomic thought, Aleksey Grigor'yevich Doyarenko was Kolyasev's first teacher. Kolyasev studied two years under Doyarenko in the experimental field of Timiryazev Agricultural Academy. Here Fedor Yefremovich made an agricultural and physical appraisal of black fallow lands and of the decomposition process of organic matter in soil.

In 1928 Kolyasev received the appointment as acting head of the Central Asian Station for Fertilizers where he organized an Agricultural Physics and Soil Cultivation Branch with the objective of providing a scientific basis for the agricultural techniques of cotton cultivation. During his work in the Uzbek SSR, Kolyasev published several scientific and popular science articles dedicated to the problems of soil cultivation under cotton.

In the Scientific Research Institute for Agrophysics, he held the following positions: Acting Head of the Institute on Scientific Research and Director of a large branch of Soil Physics and of the Laboratory on Water Regime of Soil and Plants.

He showed great interest in synthetic structure formation as a forceful method of restoring soil fertility and in the closely-related problem of the arbitrary change in the wetting quality of wettability of the soil surface. Fedor Yefremovich and his pupils have shown through many years of painstaking research that, by treating soil particles with soap-like substances, it would be easy to transfer hydrophilic soil particles into hydrophobic particles which are poorly wetted by water and which almost completely stop water filtration through soil mass.

Later, Kolyasev paid much attention to several other methods in agriculture, particularly to the large organo-mineral granules as an efficient method of increasing the effectiveness of organic and mineral fertilizers and of improving substantially the water regime of vegetables and potatoes. In the large granules composed of organic and mineral fertilizers, the nutrient elements were available to crops in large quantities but, at the same time, owing to a comparatively high concentration of salts in the granule, water vapor steadily condensed to the point of becoming sufficiently liquid to form drops, and this increased the use of fertilizers and improved the water regime of crops.

With inexhaustible enthusiasm Fedor Yefremovich conducted laboratory and field studies on granule effectiveness and introduced this method into the practice of Kolkhozes and Sovkhozes. His articles in journals and newspapers, his appearances at meetings, on radio, at All-Union conferences were invariably aimed at making his method known to the public.

It is difficult to list all the problems with which Fedor Yefremovich concerned himself during his creative lifetime.

In the Agricultural Physics Institute the main theme of all of Kolyasev's research was the problem of the water regime of soils and plants, especially the movement of soil moisture, its availability to plant at different stages of soil moisture, evaporation and soil water condensation processes, transpiration of plants and means of regulating all these processes in order to increase yields as much as possible.

The first model experiments were set up in order to study the patterns of moisture transfer in the soil, its density and temperature; next, he made a very complex study of water evaporation from the soil. Using an apparatus which he had especially designed, he constructed curves showing the dependence of evaporation rate upon the moisture of a soil sample. These curves showed that only in excessively wet soil does the evaporation value depend upon external conditions and not upon soil moisture. With a decrease in soil moisture the evaporation rate drops and a transition from one evaporation rate to another occurs by leaps and bounds so that we see on the curve clearly expressed points of sudden change. Fedor Yefremovich considered that these points of discontinuity on the curve were coordinated with well-known hydrological characteristics of the soil: field moisture capacity, moisture of the capillary break-off, etc. Based on this, a laboratory method for determining hydrological constants from a curve on soil-drying was proposed.

Fedor Yefremovich by his experimental research under Povolzh'ye conditions suggested a method of soil cultivation in layers and then centered his attention on methods of soil rolling.

He showed by experiments that soil compaction, involving a lowering of total porosity, decreases the vapor diffusion rate, and consequently, the evaporation rate. The transfer of iquid moisture towards the vaporizing surface may be stopped by lightly harrowing the rolled surface. This method soil rolling was gradually introduced into agricultural practice and, f, now, our industry is turning out a large number of different rollers which are being widely used on old and newly reclaimed lands, we can thank Fedor Yefremovich. Realizing hat without present-day methods and apparatus we could not create a new agricultural technology, he not only rendered every kind of assistance to new instrument making, but he even abored unceasingly to create new methods and instruments. Well-known in literature are Kolyasev's hygrometer and his apparatus for field measurement of the true value of water evaporation from soil. Kolyasev's apparatus for field determination of soil moisture, production of which has been taken over by one of the factories in Rostov-on-the-Don, is enjoying great popularity.

During the last eight years of his creative scientific work (1950-1958), Fedor Yefremovich conducted several large-scale comprehensive studies of the water regime of soils in the Saratovskaya, Rostovskaya, and Leningradskaya Oblasts in order to work out efficient methods for regulating the water regime. Colleagues of the All-Union Institute for Plant Physiology, All-Union Scientific Research Institute of Hydro-Engineering and Land Reclamation under the direction of Ye. G. Petrov, took part in these studies. Not only were soil and plants the subjects of study, but also all the external factors of plant life (radiation balance, temperature and moisture of soil and of the surface layer of air, wind velocity, etc.). These studies afforded much valuable data for determining the soil moisture range optimal for transpiration and growth of plant mass, standards and periods for irrigating grain crops.

Kolyasev published about 150 scientific works and had as many as ten inventions.

Fedor Yefremovich was well-known as a scientist who constantly strove to introduce the achievements of science and advanced methods into production. He was well-known in the wide circle of agronomists as an experienced teacher, whose lectures met with great success at the Leningrad Agricultural Institute and at special agronomic conferences. He was a prominent social worker. He worked many years in the Leningrad Oblast' Trade Union of Higher Education; he was chairman of the Leningrad Branch of the Society for Agriculture; he was Director of the Soil Physics Section of the Leningrad Branch of the Society of Soil Scientists.

Fedor Yefremovich was a great learned, indefatigable worker. Not only the creation of new theories and methods of study but, first of all, the usefulness of his studies to the nation formed the basis of his entire life.

YEVGENIY VASIL'YEVICH BOBKO (1890 - 1959)

By a Group of Comrades

Yevgeniy Vasil'yevich Bobko was born of a peasant family. Upon completion of classical preparatory school (town of Ostrog, Volynskaya Guberniya) he entered the natural branch of the Department of Physics and Mathematics of Kiev University in 1907. He completed the university with a specialty in chemistry in 1912 and in the same year entered the Agronomic Division of Moscow Agricultural Institute (now the Timiryazev Agricultural Academy). Upon completion of the Academy in 1914, he remained with the Academy's chair of Private Agriculture in preparation for scientific research under the direction of D. N. Pryanishnikov. From 1918 through 1924 he was an instructor in the same department. In 1924 Bobko was selected as professor in the Department of Agronomic Chemistry at Kharkov Agricultural Institute. From 1925 through 1929 he was professor in the Department of Private Agriculture at the Siberian Agricultural Institute in Omsk. In 1929 he returned to Moscow and began to head the Agronomic Branch of the Central Scientific Research Institute of the Sugar Industry (TSINS). In 1931, Yevgeniy Vasil'yevich transferred to the All-Union Institute of Fertilizers, Soil Science and Agricultural Engineering (VIUAA), People's Commissariat of Agriculture, USSR, where until 1948 he was acting head of the Laboratory of Mineral Fertilizers and at the same time supervised the Micronutrient Fertilizer Division. During the period 1941-1946, he also headed the Laboratory of Mineral Nutrition, Institute for Plant Physiology, Academy of Sciences, USSR.

After leaving VIUAA, Bobko worked from 1949-1959 as editor of the Institute for Scientific and Technical Information, Academy of Sciences, USSR. In 1928, Yevgeniy Vasil'yevich was detailed to Germany for four months where he became acquainted with establishing scientific-research and educational work in the field of agricultural chemistry. In 1934, he was confirmed in the scientific degree of Doctor of Agricultural Sciences in the field of "Agricultural chemistry" without supporting his thesis and in the scientific status as an actual member of VASKhNIL (V. I. Lenin, All-Union Academy of Agricultural Sciences).

Bobko has written about 150 works. We should mention among them research on the chemical treatment of phosphorites, studies on the problem of sodium carbonate formation in soil, the method of bases adsorption by soil and factors responsible for soil reaction. He has worked out a sterile culture method for higher plants and has conducted studies on the problem of the availability to plants of soil phosphates by the method of so-called "solubility curves" and also on the problem of the fertility of Siberian soils, particularly the solonetzes.

During the period from 1929-1949, Bobko together with his co-workers conducted studies on a wide scale on the problem of the physiological role and importance of micro-elements from the fertilizer standpoint, particularly of boron (its adsorption by soils, role played in pollen germination, content in different parts of the plant, solubility of its compounds found in plants, its importance as fertilizer). A system of experiments on the study of the effectiveness of boron enabled him to establish, although only in general outline, the areas of boric fertilizer application, amounts and methods of applying them. The role of boric fertilizers in controlling the rotting of the heart of the garden beet, which is of vast scientific and productive importance, was developed for the first time by Bobko. He also conducted studies on the importance of molybdenum for the development of plants (1940-1945), importance of selenious and selenic acids and also copper, etc. To Bobko belongs several studies on separate methods used for the chemical study of soils, plants and fertilizers.

As a result of 45 years of scientific research Bobko has made a vast contribution to agricultural chemistry and plant physiology. He was a precise chemist, and like K. K. Gedroyts, loved very much to work personally in the laboratory; he tried to construct his activities "without becoming isolated from the laboratory desk."

During the last ten years of his life, Bobko did not engage in his favorite occupation — agricultural chemistry, but instead was occupied in editing foreign research papers.

Bobko trained many young people. He was a great organizer of scientific collectives and studies, particularly of a systematic nature; he was a brilliant experimenter, a modest and crystally clear person who fought his entire time for the principles of science and life.

Agricultural chemists, his numerous pupils, both followers and admirers, will deeply mourn the death of our dear Yevgeniy Vasil'yevich Bobko.

We ought to regard many of his works as classical, but at present, they are a bibliographical rarity. A published collection of his selected scientific works shall serve as our best memory of Yevgeniy Vasil'yevich Bobko.

REVIEW

NEW CONTRIBUTION TO SCIENTION TO SCIENTIFIC AND EDUCATIONAL LITERATURE — SPECIALIZED SOIL SCIENCE, BY A. MUSIEROWICZ

I. I. SINYAGIN

The book by A. Musierowicz "Specialized Soil Science," second edition, holds undoubtedly first place among the scientific literature on soil science published in 1958 in the Polish People's Republic. This book is a continuation of a work by the same author "General Soil Science" published in 1956. Together both publications represent a complete course in soil science for higher agricultural educational institutions.

At the beginning of the textbook "Specialized Soil Science" the basic problems in classifying the soils of Poland are discussed. The author points out that a great share of working out problems belongs to the famous Polish soil scientists S. Miklashevskiy, T. Mechinskiy, and also to the Polish Society of Soil Scientists, which systematically deals with the problem of classifying soils of Poland. As the author indicates, in working on problems of soil classification, he has devoted his attention also to studies that have been carried out in the Soviet Union.

Musierowicz separates two groups of soils in Poland — the soils of lowland and mountain districts. The group of lowland soils includes: 1) soils of the initial period of soil formation, 2) podzolic soils, 3) brown forest soils, 4) chernozems, 5) dark-colored soils, 6) rendzinas, 7) hydromorphic (bog) soils, and 8) non-water-logged soils of river flood plains (bottom lands). The author also separates similar groups of soils for mountain districts. However, in these districts under the conditions found in Poland, there are no soils which could be related to the chernozem group. The soils of the Poloninskiye Mountains are an additional group here.

The characteristics of the podzolic soils in Poland occupy a large part of the book. The author analyzes in detail the specific characteristics of the soil-forming process under various conditions. He examines this process, basically conforming to the scheme of V. R. Vil'yams, according to which, as we know, the biochemical processes associated with the decomposition of forest litter under the influence of fungus microflora play the chief role in the formation of the profile of podzolic soils. Discussed fairly in detail are the results of the observations of Yu. Tomashevskiy and S. Yarkov who have defined more precisely the conditions required for the realization of soil podzolization. The author distinguishes the sod-podzolic gley soils as a separate subgroup of podzolic soils.

The book gives a detailed classification of sod podzolic soils according to texture, degree of podzolization, character of the soil-forming and underlying parent material, and also with respect to the processes of soil change as a result of agricultural use. Musierowicz dwells particularly in detail on a description of the podzolic soils of coarse texture, which are basically widespread in Poland. He brings in many analyses of the chemical composition and physical properties of these soils taken from the various districts in the Polish People's Republic.

The characteristics of the genesis and basic varieties of brown forest soils of Poland and plays an important part in Musierowicz's book. The author shows the genetic relationship between brown forest soils and both chernozems and dark-colored soils and podzolic soils. The brown soils under the influence of meadow vegetation are transformed first into gray-brown soils and then into dark-colored soils.

If the development of the sod process is not associated with meadow vegetation, but with meadow-steppe vegetation, the transformation of brown soil into chernozem is, in the final analysis, a result of this. Where the leaching processes are intensified (which may be associated with an increase in soil moisture and development of forest vegetation) the ordinary brown soils acquire features of leached brown soils. Further development of these processes leads to the formation of podzolized soils.

Polish soil scientists, as a rule, have

separated the varieties of chernozem which differ by degree of degradation. Thus, Miklashevskiy differentiates: the nondegraded or weakly-degraded chernozems, chernozems with a developed degradation process and the podzolized soils. In the classification adopted by the Polish Society of Soil Scientists and to which Musierowicz basically adheres, the chernozems of Poland have been subdivided into two basic groups: 1) the ordinary chernozems (the nondegraded or very weakly-degraded), and 2) degraded chernozems. Related to the second group are also the strongly-leached varieties with clear signs of podzolization. Each of these groups has been further subdivided according to the character of the soil-forming parent material and texture. The book offers ample factual data describing the properties of the chernozems of Poland.

The author of the book clearly distinguishes the dark-colored soils from the present chernozems, and considers that the present chernozems are genetically associated with hydromorphous soils. He calls the strongly-degraded dark-colored soils gray soils. Musierowicz associates their formation with an intensified aeration of the dark-colored soils during agricultural use which leads to the mineralization of a large part of the humus. The degradation of dark-colored soils occurs also under the influence of a coniferous forest whereby the formation of podzolic soils may be the final stage of this process. Musierowicz admits the possibility of a gradual transformation of gray soils into dark-colored soils and then into humic-gley soils and, finally, into bog soils under the influence of a rising and intensifying ground moisture. He describes in detail many varieties of gray and dark-colored soils, referring to many analyses of samples taken from the various districts in the Polish Peoples' Republic.

The rendzinas are, as we know, one of the typical soil formations in Poland. They differ depending upon the character of the soil-forming parent material, texture, and thickness of the fine-earth layer. The rendzinas of the chernozem and brown earth groups and the so-called white rendzinas differ from respect to a varying humus content. The white rendzinas usually emerge as a secondary formation associated with the erosion processes, which reveal deeper weakly-humified horizons in these soils. Moreover, the cretaceous, Permian, Devonian and other rendzinas differ depending upon the origin of the soil-forming parent material.

A description of the non-water-logged flood plain or bottom land soils known in Polish literature as "Mady" occupies an important place in Musierowicz's book. He distinguishes the young soils of bottom land areas which are being periodically inundated by spring high water (spring freshets) and also the soils which have emerged from under the influence of annual flooding. Among these latter soils are distinguished the chernozem-like, brown earth-like, and podzolized bottom-land soils. These soils have been described in detail according to texture of the alluvial deposits on which they have been formed.

With respect to a description of the bottom-land (flood plain) soils, Musierowicz briefly mentions also the marshes (or polder soils) which have a certain distribution in the marine districts of Poland. Similarity of features between the marshes and the soils of river bottom lands is, to a certain extent, pointed out by the actual name given to these soils — the marine mayds.

The hydromorphous (bog) soils are analyzed in many Polish studies. A detailed classification of peat-bog soils of different origin and age is given. The process of the gradual mineralization of peat soils is described; the author of the book examines the soil varieties which are the result of this process. The mountain soils are described approximately in the same way as the lowland soils, the specific characteristics of soil formation in the Sudetskiy, Sventokzhitskiy and Karpatskiy mountain districts are studied.

Besides genetic characteristics of the soils and a description of their general properties, much attention is devoted to the agronomic characteristics of the soils. Directions for the most expedient use of soil in agriculture and forest economy are given in describing each soil.

The site index system of soils adopted in Poland is described in detail in the textbook. The plowed soils and soils used for natural forage (meadows and pastures) and also soils found under forest, and water, are divided into six classes. The first class is the highest in each soil group according to character of soil use, the sixth class is the lowest. Subclasses are formed, within certain classes, which enable one to determine more precisely the site quality of soil. The site index scales for plowed soils are given separately for the lowland soils and the soils of mountain districts. Each soil group (chernozem, sod-podzolic soil, rendzina, etc.), indicated to which site classification category one or another variety should be related.

Less detailed than the soils of Poland are the descriptions of the soils of other nations which are related to different natural zones, particularly, the tundra soils, the soils of dry and desert steppes (chestnut and brown soils, sierozems, salinized, laterite soils, red earths and yellow earths, etc.). In describing these soils Musierowicz uses extensively works of Soviet soil scientists and draws also on the data of Hungarian, German, American, and other authors. The book has a voluminous list of soil science literature, published in Poland, the USSR and other countries. Appended to the book is a soil map of Poland on a scale of 1:1,000,000. Based on a soil map of Poland on a scale of 1:300,000, this map was compiled by a large group of Polish soil scientists and edited by Musierowicz.

Musierowicz's book is proof of the extensive development of soil studies in the Polish People's Republic. Combining the results of many years' research by Polish soil scientists, with the wide attraction of soil science achievements in adjoining countries, will lend great scientific value to this work. At the same time this book is a valuable text for universities.

From the group of soils which have been studied little under our conditions (the rendzinas, forest brown earths, bottom-land soils, etc.), specialists will find in much interesting new data Musierowicz's book which will enable one to understand more profoundly the specific characteristics of the genesis and properties of these soils. A positive argument for the book is the fact that in it the specific characteristics of the genesis of one or another soil is closely associated with the soil's agronomic properties and agricultural use.

With regard to the great interest which is presently being shown in our country in problems on agronomic characteristics and soil site quality, Musierowicz's study undoubtedly will attract the serious consideration of our soil scientists and agronomists both with respect to a systematic approach to the problems given, and from the viewpoint of using the results of research of Polish soil scientists in adjoining rayons of the USSR.

It is hoped that the soil scientists of our country have had an opportunity to become acquainted with this outstanding work of a famous Polish soil scientist. A translation and publication into Russian of Musierowicz's book seems to us to be certainly useful and indispensable.

BIBLIOGRAPHY

BIBLIOGRAPHY

FACTORS OF SOIL FORMATION, GENESIS AND GEOGRAPHY OF SOILS

1. ABRAMOVICH, D. I. 1958. Study of the waters of Western Siberia. Izv. otd. Geogr. Obshchestva SSSR. (2):11-12. Bibliog. 40 refs.

2. ASHIRAKHMANOV, SH. 1958. Vertical zonality of soils of the northern slope of the Ala-Too in the Chon-Keminskaya valley. Trudy molodykh nauch. rabot. Akad. Nauk. Kirghiz SSR. Frunze, pp. 267-270. Bibliog. 5 refs.

3. BRIVKALN, K. 1959. Soils of Latvian SSR. Mapping and use of cartographic data in agriculture. Latgosizdat. Riga. 171 pp. with illustr. and maps. Bibliog. pp 167-168. In Latvian.

4. KOLODYAZHNAYA, A. A. 1958. Effect of sulfides on the Karst formation processes. Trudy laboratorii gidrogeologicheskikh problem im. Savarenskogo, 16: 327-335. Bibliog. page 335.

5. LANGE, O. K. 1955. Regional patterns of ground-water formation. (Doklady na Soveshchanii po voprosam formirovaniya podzemnykh vod. April). Ibid, pp. 187-193.

6. MEZENTSEV, V. S. 1958. Data on studies of moisture conditions in Western Siberia. Izv. Novosib. otd. Geogr. o-va SSSR, 2:43-50 with maps.

7. KOPOSOV, I. P. 1958. Natural historical regionalization of Ul'yanovskaya Oblast'. Trudy Ul'yanovskogo Sel'skokhoz instituta. 5 (2):315.

8. SELYAKOV, S. N. and I. G. ZAL'TSMAN. 1959. Buried quaternary soils of the Priobskoye plateau. Izv. Sib. otd. AN SSSR. (1):91-102.

9. STEPANOV, I. N. 1959. Snow cover as a factor in the formation of loess-like fingergrained strata. Doklady AN SSSR. 125(1):153-154.

10. TATEVOSYAN, G. S. 1959. Soils of the Shamshadinskiy Rayon, Armyanskaya SSR. Author's summary of a dissertation for a candidate's degree in biological sciences. (Kishinevskiy Gosodarstvennyy Universitet), Kishinev. 16 pp.

11. TETERINA, L. V. and YE. I. CHERNYAK. 1958. Soils of the basin of the lower courses of the Yakokit River. Trudy instituta biologii. (Yakutskiy filial Sib. otd. AN SSSR.) (5):5-44. Bibliog. 7 refs.

12. FOURNIER, F. et S. HÉNIN. 1959. Nouvelle formule oroclimatique pour apprécier la dégradation spécifique des terres. C. r. Acad. Sci. 248(11):1695-96.

13. The Future of arid lands. 1956. Papers and recommendations from the International arid lands meetings. Washington, 453 pp, 2d, print. 1957.

14. GIBBS, H. S. 1959. Soil surveys, N. Z. J. Agric., 98, N 1, 9-13 pp.

15. GILE, L. H. 1958. Fragipan and water-table relationships of some brown podzolic and low humic-gley soils. Soil Sci. Soc. America Proc., (22):6, 560-65

16. HAMBLOCH, H. 1958. Über das Alter und die Bildungsdauer von Eisenhumuspodsolen. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 83(128): Ht. 2, S. 134-39.

17. HAMMOND, L. C. a. oth. 1958. Soil sampling in relation to soil heterogeneity. Soil Sci. Soc. America. Proc., (22):6, 548-552.

18. HONG, T. H. and J. VAN SCHUYLENBORGH. 1959. On the classification and genesis of

soils, derived from andesitic volcanic material under a monsoon climate. Netherl. J. Agric. Sci. 7(1):1-21. Bibl. 50 t. t.

19. HUBBLE, G. D., R. F. ISBELL. 1958. The occurrence of strongly acid clays beneath alkaline soils in Queensl. Austral. J. Sci., 20(6)pp. 186-87.

20. ISBELL, R. F. 1958. The occurrence of a highly alkaline solonetz soil in Southern Queensland. Queensl. J. agric. Sci., 15, 15-23 pp.

21. LAG, J., J. PAG. 1958. Preliminary report on calculations of quantitative, relationships between soils and soil-forming factors. Acta agric. scand., (8):3, 279-84.

22. LAGOS, A. M. 1958. Vergleichende Untersuchungen über eine wichtige chilenische Bodenform und ahnliche Bildungen in Spanisch-Guinea und auf den Kanarischen Inseln. Z. Pflanzenernähr., Düng., Bodenkunde, Bd 83(128), Ht. 2, 97-103 pp.

23. LANDSBERG, H. E. a. M. L. BLANC. 1958. Interaction of soil and weather. Soil Sci. Soc. America. Proc., v. 22, N 6., 491-495.

24. MÜCKENHAUSEN, E. 1959. u. an. Entstehung und Eigenschaften der Böden auf den fossilen Verwitterungsdecken der Eifel. — Z. Acker. und Pflanzenbau. 108, Ht. 1/2, S. 201-22. Bibl. 25.

25. NORTHCOLTE, K. H. 1958. The morphology of redbrown earths. Soils News aust. soc. Soil Sci., N 4, p. 2-11.

26. SCHAUFELBERGER, P. 1958. Die Bodenklassifikation in geologischer und petrographischer Betrachtungsweise. Neues Jahrb. Geol. - und Paläontol. Monatsch N 3-4, S. 155-71.

SOIL MINERALOGY

27. MITYUNIN, YU. K. 1958. Method of photographing macro-objects by polarization microscope. (Study of minerals) Uchen. zap. (Leningradskiy Pedagogicheskiy institut Im. Gertsena 172:239-260.

28. BRYDON, J. E. and P. E. MARSHALL. 1958. Mineralogical study of Lindley soil in Missouri 1957. 38 p. (Missuri agric. Exp. Sta. Res. Bull. 623) Ref.: J. Sci. Food and Agric. 9(10):11-146.

29. CARROLL, D. 1958. Role of clay minerals in the transportation of iron. Geochim. et cosmochim. acta. 14p. 1-28.

30. MORTLAND, M. M. 1958. Kinetic of potassium release from biotite. Soil Sci. Soc. America. Proc., v. 22, N 6, pp. 503-508.

PHYSICAL PROPERTIES OF SOILS, AND METHODS OF INVESTIGATION

31. AKOPOV, YE. S. 1958. Water filtration into soil during a varying water discharge regime in an irrigation ditch. Trudy Armyanskogo Nauch. issledovatel'skogo Instituta gidrotekhn. i melioratsii 3:219-229.

32. ALEKSANDRYAN, V. V. 1958. The determination of evaporation from the soil surface. Trudy Armyanskogo nauch. issledovatel'skogo Instituta gidrotekhn. i melior. 3:281-284.

33. BORODULINA, T. G. 1959. Study of form of bond water to soil particles using the radioactive isotope method. Zhurnal tekhnicheskoy fiziki. 29(3):365-373.

34. GOLUB, T. F., and N. I. KURILENKO. 1958. Respiration activity of waterlogged and peat-bog soils. Trudy instituta (Belorusskiy nauchnyy issledovatel'skiy Institut melioratsii vodnogo khozyaystva) 9:167-177. Bibliog. page 177.

35. GRAZHIS, I. I. 1959. Principles of regulating the water regime on the flood-plain meadows of the lower course of the Nemunas River. Author's summary of a dissertation for candidate's degree in Agricultural Sciences. (Litovskiy Sel'skokhoz. Institut) Moscow. 22 pp.

36. 1957 Yearbook on precipitation, air temperature and moisture reserves in the soil of the Odesskaya Oblast'. 1958. (Odesskaya Oblast' S. Kh., Byuro Pogody) Odessa. 60 pp.

37. ZNAMENSKAYA, N. S. 1958. The hydrological role of narrow strip plowing. Trudy instituta (Serv. nauchnyy issledovatel'skiy institut gidrotekhn. i melioratsii). (15):25-37.

38. ZYUL'KOV, G. I. 1958. Effect of the water regime of peat-bog soils on agricultural crop yields. Trudy instituta (Belorusskiy nauchnyy issledovatel'skiy institut meliorat sii i vodnogo khozyaystva) 9:219-229. Bibliog. 15 refs.

39. IVITSKIY, A. I. 1958. Two-way regulation of the water regime of peat soils. Trudy instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva) 9:3-24. Bibliog. 13 refs.

40. KOSTYUKEVICH, N. I. 1959. Hydrological role of the Poles'ye forests. Author's summary of a dissertation for doctor's degree in Agricultural sciences. (AN BSSR, Institut biologii) Minsk. 20 pp.

41. LATARIYA, V. N. 1958. Change in the carbon dioxide content of soil air under grassland crop rotation conditions. Soobshcheniye AN Gruz. SSR. 21(5):575-582. Bibliog. 7 refs.

42. MAKOVSKIY, M. V. 1958. The water discharge problem of peat soils. Trudy Instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva). 9:101-117. Bibliog. 14 refs.

43. RAKHMANOV, V. V. 1959. Effect of the forest on ground waters. Ratio of ground water levels in the forest and on open terrain. Trudy Tsentral'nogo Instituta Prognozov. (82):83-130. Bibliog. 96 refs.

44. BIJKERK, C. 1958. Hydrological aspects of the Drenthe soil types. Landbouwkund. Tijdschr. 70:858-72.

45. BORGUE, E. le et G. MONNLER. 1959. Influence du feu sur certaines propriétés du sol. C. r. Acad. sci., 248 10, 1549-51.

46. BOURGET, S. J. 1958. a. oth. Electrical resistance units for moisture measurements: their moisture hysteresis, uniformity and sensitivity. Soil Sci. v. 86, H 6, pp. 298-304.

47. CANNELI, G. H. 1958. Effect of drying cycles on changes in resistance of soil moisture units. Soil Sci. Soc. America Proc., v 22, N 5, p. 379-382.

48. CHEN, CH. 1958. A primary study of permeability of structureless soil to air. Acta pedol. sinica, v. 6, N2. p. 123-36.

49. FINKEL, H. J. and D. A. NIR. 1958. A modified diffusion-cup method for sampling soil air. Soil Sci., v. 86, N 6, p. 332-335. Bibl.

50. GREACEN, E. L. 1959. The strength of cultivated soil. J. Agric. Engin. Res., 4, N 1, 60-61.

51. ISRAELI, H. 1958. Die natürliche Radioaktivität in Boden, wasser und Luft. Beitr. Phys. Atmosph., 30, N 2-3, pp. 177-188.

52. JACKSON, R. D. and D. KIRKHAM. 1958. Method of measurement of real thermal diffusivity of moist soil. Soil Sci. Soc. America Proc., v. 22, N 6, pp. 479-482.

53. JANERT, H. 1958. Die Anwendung von Methanol bei physikalischen Bodenuntersuchungen. Z. Pflanzenernähr., Düng, Bodenkunde, Bd. 83(128): Ht. 2, S. 124-34.

54. KAMAT, B. D. 1959. Effect of the application of krilium (soil conditioner) on the erosion behaviour of clayey and alkaline soils. Indian J. Agron., N 1, p. 37-40.

55. KMOCH, H. G. u. A. MAZURAK. 1959. Zur Bedeutung der Methodenwahl bei Untersuchung der Bodenporositat. Z. Acker. - und Pflanzenbau, 108, Ht. 1/2, S. 137-48, Bibliog. 21 n.

56. LOW, PH. F. and D. M. ANDERSON. 1958. Osmotic pressure equations for determining thermodynamic properties of soil water. Soil Sci., vol. 86, N p. 251-253.

57. MILLER, E. E. and D. E. ELRICK. 1958. Dynamic determination of capillary conductivity extended for non-negligible membrane impedance. Soil Sci. Soc. America Proc., v. 22, N, 6, pp. 483-86. Bibl.

58. MONRANI, V. 1957. La strutture del soulo ed i suoi fattori. Italia Agric., 94, N 7, p. 579-590. Bibl. 28 tit.

59. NIELSEN, D. R. and R. E. PHILLIPS. 1950. Small fritted glass bead plates for determination of moisture retention. Soil Sci. Soc. America Proc. v. 22, N 6, pp. 574-75.

60. PORTH, H. 1959. Wie lässt sich die Struktur der mittleren Böden verbessern? Mitt. Dtsch. Landwirschafts- Ges., 74, Ht, 15, C 423-25.

61. REYNTENS, H., H. DIERICK. 1958. Influence de la couverture du sol sur l'humidité du sol. Rev. Agric. Brux. 11, pp. 818-827.

62. TANNER, C. B. and D. E. ELDRICK. 1958. Volumetric porous (pressure) plate apparatus for moisture hysteresis measurements. Soil Sci. Soc. America Proc., v. 22, N 6, pp. 575-576.

63. WILL, G. M. 1959. Soil-moisture and soil-temperature studies under radiata pine, Whakarewarewa forest, N. Z. J. Agric.

64. ZWERMAN, P. J. and G. R. BLAKE. 1958. An index to Forschungen auf dem Gebiete der Agrikulturphysik. (Research in agricultural physics, 1878-1898). Soil Sci., v. 86, N 6, pp 350-354.

SOIL CHEMISTRY AND METHODS OF ANALYSES

65. AYDAROV, T. K., A. YE. ZAK, and YE. S. SAFONOVA. 1959. Effect of certain elements in determining alkali metals using the flame photometry method. Zavodskaya laboratoriya. 25(3):269-271.

66. ANANYAN, G. T. 1958. Chemistry of soil ground waters of the northern area of the Arazdayanskaya steppe. Trudy Armyanskogo nauchnogo issledovatel'skogo instituta gidrotekhniki i melioratsii. 3:269-279.

67. BRYLEV, V. K. 1959. Soil moisture by melt waters of the Priobskaya forested steppe. Izv. Sib. otd. AN SSSR. (1):107-116. Bibliog. 14 refs.

68. BUGUBAYEV, A. B. 1958. Physicochemical studies of peat in the deposits of Frunzenskaya Oblast', Kirghizskaya SSR. Trudy molodykh nauch. rabot. AN Kirghiz SSR. Frunze. pp. 177-185. Bibl. 6 refs.

69. IONOVA, V. N. 1959. Physical soil propperties of chernozems and their use for perennial plantings. Sadovodstvo, vinogradarstvo i vinodeliye Moldavii. (1): 6-8.

70. KULAKOVSKAYA, T. N. 1958. A method of determining potassium by the cobaltinitrate process. Trudy instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva). 9:253-257. Bibliog. page 257.

71. SKRIPKIN, A. A. 1958. Apparatus and method for determining the energy of organic matter decomposition in the soil. Trudy instituta. (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva). 9:259-268. Bibl. page 268.

72. ABRUNA, F. 1958. a. oth. Quantitative evaluation of soil reaction and base status changes resulting from field application of residually acidforming nitrogen fertilizers. Soil Sci. Soc. America. Proc. No. (6):22:539-542.

73. AGRINIER, H. 1958. Determination semiquantitative du vanadium dans les sols par chromatographie ascendante sur papier. C. r. Acad. Sci., 246, No. (19):2761-2763.

74. ALBAN, L. A. and O. J. – Y., LIN. 1958. Effect of lime additions on pH and base saturation of five western Oregon soils. Soil Sci. 86 No. (5):271-275.

75. Aluminum in soils. I. Extraction methods and magnitudes in clays and Ohio soils. Soil Sci. Soc. America Proc. 22 No. (5): 382-87.

76. BERNIER, B. 1958. Characterization of polysaccharides isolated from forest soils. Biochem. J., 70 No. (4):590-598. Bibl. 43 tit.

77. BURRIEL, M. F. 1958. a. oth. Sobre la determinacion de boro en suelos y plantas. I. Mētodo colorimétrice de analisis. An. Real. Soc. esp. fis. y quim., B54, No. (1):35-42.

78. CLARK, L. J., W. L. HILL. 1958. Occurrence of manganese, copper, zinc, molybdenum, and cobalt in phosphate fertilizers and sewage sludge. J. Assoc. offic. agric. Chemists. Wash., 41:631-637.

79. DEUEL, H. and P. DUBACH. 1958. Dekarboxylierung der organischen Substanz des Bodens. 2. Nachweis von Uronsären. Z. Pflanzenernähr., Düng., Bodenkunde, Bd 82(127): 97-106.

80. DHARIWAL, A. P. S. and F. J. SREVENSON. Determination of fixed ammonium in soils. Soil Sci., 86 No. (6):343-349.

81. DOLL, W., H. SPECKER. 1958. Spurenanreicherungen in Ackerböden mit selektiver Abtrennung von Eisen. Z. analyst. Chem. 161 No. (5):354-362.

82. EHRENBERGER, F. 1958. u. a. Beiträge zur mikroanalytischen Bestimmung des Sauerstoffes in organischen Substanzen. Mikrochim. acta, Ht. 6 778-788. Bibl.

83. FRENSEY, J. R. 1958. Determination of water-soluble sulfate in soils. Soil Sci., 86 No. (5):241-244.

84. FRIED, M. 1958. a. oth. The relationship between adsorption and absorption of cations. Soil Sci. Soc. America Proc., 22 No. (6):495-499.

85. GETTKANDT. G. 1958. Eine schnell durchfährbare flammenphotometrische Calciumbestimmung im salzsauren Bodenauszug. Landwirtsch. Forsch., 11, 93-95.

6. GYÖRI, D. 1958. The supply of trace elements in some soil types. Agrokém. és talajt., 97-110.

7. HAUCK, R. D. 1958. a. oth. Use of N-isotope distribution in nitrogen gas in the study of denitrification. Soil Sci., v. 86, N 5, 1958, p. 287-91.

8. HENRICKSEN, A. and H. L. JENSEN. 1958. Chemical and microbiological determination of copper in soil. Acta Agric. scand. 8 No. (4):467-469.

9. HILL-GOTTINGHAM, D. G. and C. P. LLOYD-JONES. 1958. Behaviour of iron chelates in calcareous soils, 3. Laboratory experiments with a further range of chelating agents. Plant and Soil., v. 10 No. (2):194-204.

0. HUTTON, J. T. 1958. Chemistry of red brown earths. Soil News aust. Soc. Soil Sci. No. (4):11-18.

1. JACKSON, M. L. 1958. Soil chemical analysis. N. J. 512 pp.

2. KUBOTA, J. and V. A. LAZAR. 1958. Cobalt status of soils of south-eastern United States. 2. Ground-water podzols and six geographically associated soil groups. Soil Sci., v. 86 No. (5):262-68.

3. LICHTENSTEIN, E. P. and K. R. SCHULZ. 1958. Colorimetric determination of Heptachlor in soils and some crops. Agric. and Food Chem., 6 No. (11):848-849.

4. MÄKITIE, O. and L. LAPPI. 1958. On the effect of matrix composition on the spectrochemical analysis of soil and plant ashes. Helsinki, 36 pp.

5. McHENRY, J. R. 1958. Ion-exchange properties of strontium in a calcareous soil. Soil Sci. Soc. America, Proc. 22 No. (6): 514-518.

6. MARSHALL, C. E. Physico-chemical properties of solidiliquid interfaces in soil systems. Ibid., 486-490 pp.

7. MATELSKI, R. P. and C. H. YIEN. A rapid field and laboratory procedure for determining the sodium content of soil. Ibid, pp. 500-502. Bibl.

8. PERKINS, A. T. Effect of phosphate on the cation-exchange capacity of minerals and soils. Ibid., pp 509-511.

9. PIOLANTI, G. 1958. L'analisi fisico-chemica dei terreni nelle zone bieticole. Prog. Agric., 4 No. (12):1422-1429.

100. SCHACHTSCHABEL, P. 1958. u. an. Chemische Untersuchungen an Marschen. I. Boden des Niederelbegebietes. Z. Pflanzenernähr., Düng., Bodenkunde, Bd 83(128), Ht. 2, 103-24 Bibl.

101. SCHACHTSCHABEL, P. u. W. KÖSTER. Chemische Untersuchungen an Marschen. 2. Boden des Ems- und Weser-Jade-Gebietes. Ibid, Ht 3, 203-214.

102. SCHOELLER, M. 1958. Variation de la composition chimique des solutions des sols suivant les horizons pédologiques. C. r. Acad. Sci., 246 No. (15):2276-2277.

103. SCOTT, R. O. and A. M. URE. 1958. The determination of magnesium in solution by direct photometry. Analyst, 83 No. (991):561-70.

104. SCHEFFER, F. 1958. u. an. Uber Synthesehuminsäuren aus Polyoxybenzole. 3. Mitteilung. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 82 (127), Ht. 2/3, 193-205. Bibl.

105. SPRINGER, U. 1958. Vereinfachung des Sulfazetolyse-Verfahrens zur Bestimmung der Huminstoffe. Pflanzenernähr. Düng., Bodenkunde, Bd. 82(127), Ht. 2/3, 205.

106. SPRINGER, U. and J. KLEE. 1958. Die gleichzeitige Bestimmung von Kohlenstoff und Stickstoff beim Schnellverfahren nach Springe und Klee. Z. Pflanzenernähr Düng., Bodenkunde, Bd. 82(127), Ht. 2/3.

107. SZǓEST, L. 1958. A rapid method of soil analysis. Agrokém, és. Talaj. 1958, 7, No. 2. pp. 189-198. (In Hungarian) Summary in Russian. Ref. Khimiya 1, No. 3. 8022.

108. TAYLOR, A. W. 1958. Some equilibrium solution studies on Rothamsted Soils. Soil Sci. Soc. America Proc., 22 No. (6): 511-13.

109. TING, C. P. and T. J. YU. 1958. Studies on oxidation-reduction processes in paddy soils. 4. The activities of iron and manganese in paddy soils derived from red earth. Acta pedol. sinica, 6 (2):99-107.

110. VAVASSORI, A. M. 1959. L'analisi fisico-chemica dei terreni per più razionale impiego dei fertilizzanti. Progr. Agrocolo. 5 No. (1):69-73.

111. WAHHAB, A. and H. M. BHATTI. 1958. Trace element status of some West Pakistan soils. Soil Sci., 86 No. (6):319-23.

112. WANG, S. C. C. S. YEH. 1957. The affinity of soil colloids of Taiwan saline alluvial soils for different cations. Taiwan Sug. Exp. Sta. 15 pp. 1-16.

BIOLOGY AND SOIL MICROBIOLOGY

113. GRODZINSKAYA, K. P. 1959. Role of soil microflora in improving conditions of manganese plant nutrition. Author's summary of a dissertation for candidate's degree in biological sciences. (AN/Ukr SSR otd. biologicheskikh nauk). 16 pp.

114. First All-Union Conference on problems of soil zoology. 1959. (AN SSSR. otd. biologicheskikh nauk, institut morfologii zhivotnykh). Moscow. 11. pp.

115. TOROPKINA, A. 1959. Effect of basic soil cultivation methods on microflora development. Khlopkovodstvo. (3):31-35.

116. SHUPEN, V. K. 1958. Effect of certain land improvement measures on nitrification conditions in podzolic-gley fine-textured soils. Trudy Instituta (Severnyy nauchnyy issledovatel'skiy institut gidrotekhniki i melioratsii). (15):59-82.

117. ABD-EL-MALEK, Y, and S. G. RIZK. Counting of sulphate-reducing bacteria in mixed bacterial populations. Nature, 182 No. (4634):538.

118. BURRICHTER, E., 1958. Seasonal variations in the quantity of soil bacteria. Ber. Dtsch. bot. Ges., 71 No. 2, pp. 71-80.

119. DOMSCH, K. H. 1958. Die Prüfung von Bodenfungiciden. I. Pilz — Substrat — Fungicid — Kombinationen. 2. Pilz — Boden-Wirt — Fungicid — Kombinationen. Plant and Soil, v. 10 No. (2):114-16.

120. HENIN, S. 1959. et aut. Un aspect de la dynamique des matières organiques du sol. C. r. Acad. Sci. 248, No. (1):138-141. Bibl. 4 tit.

121. HOBBS, J. A. 1958. Humus losses in great plains soils. Crops and Soils. 11 No.(3): 14-15.

122. HOFER, A. W. 1958. Selective action of fungicides on rhizobium. Soil Sci. 85 No. (5):282-86.

123. HUNTER, A. H. Nutrient absorption and translocation of phosphorus as influenced by the root knot nematode (Meloidigyne incognita acrita). Ibid. p. 245-50.

124. JAMES, N. 1958. Soil extract in soil microbiology. Canad. J. Microbiol. 4: 363-370.

125. LOCHHEAD, A. G. 1958. Soil bacteria and growthpromoting substances. Bacteriol. Revs. 22:145-153.

126. NATARAJAN, S. Carbon-nitrogen metabolism of soil fungi. 5. Role of cyanide, nitrit and sulphur. Proc. Indian Acad. Sci. 1958, 48:28-32.

127. PATRICK, Z. A., L. W. KOCH. 1958. Inhibition of respiration, germination, and growth by substances arising during the decomposition of certain plant residues in the soil. Canad. J. Bot. 36, pp. 621-647.

128. SPERBER, J. I. 1958. The incidence of apatite-solubilizing organisms in the rhizosphere and soil. Austral. J. Agric. Res., 9 No. (6):778-81.

129. SPERBER, J. I. Solution of apatite by soil microorganisms producing organic acids. Ibid., 782-87 pp.

130. STARKEY, R. L. 1958. Interrelations between microorganisms and plant roots in the rhizosphere. Bacteriol. Rev. 22 pp. 154-172. A review with 147 references.

131. STOTZKY, G. and J. L. MORTENSEN. 195 Effect of addition level and maturity of rye-tissue on the decomposition of a muck soil. Soil Sci. Soc. America Proc. 22 No. (6):521-24.

132. WOTTON, W. I. and H. R. McLARTY. 1958. Steam-operated equipment for the partial sterilization of soil, flats and pots. Cana Plant Sci., v. 38, No. (4):424-29.

SOIL FERTILITY, FERTILIZERS AND CULTIVATION

133. BEL'SKIY, B. N. 1958. Effect of Starobinsk potassium salt on the yields of agri cultural crops cultivated on peat-bog soils. Trudy Instituta (Belorusskiy nauchnyy issledovatel'skiy institut meliorats i vodnogo khozyaystva). 8:241-252. Bibli 8 refs.

134. VERSHININ, P. V., N. P. POYASOV, and A. N. KOSORCHUK. 1959. Soil cultivation at high speeds. Vestnik sel'skokhoz. nauki. (2):92-98.

135. VIZGIN, V. A. 1959. Periods and methods of applying phosphorus fertilizers to cott plants. Udobreniya i urozhay. (4):26-27.

36. DAMSKAYA, K. M. 1958. Physicochemical properties of dark-gray forested steppe soils of Ul'yanovskaya Oblast' with reference to their liming. Trudy Ul'yanovskogo sel'skokhoz instituta. 5(2):60-64. Bibliog. 5 refs.

37. YELOVSKAYA, L. G. 1958. Effect of soil conditions on chemistry and nutrient value of certain forage crops in central Yakutskaya, ASSR. Trudy Instituta biologii (Yakutskiy filial Sibirskogo otdeleniya AN/SSSR) (5):45-115. Bibliog. pp. 113-115.

38. KIKIN, A., and P. KULEBAKIN. 1959. Resistance of soil cultivating machines and equipment on solonetzes. Sel'skoye khozyaystvo Sibiri. (2):57-62.

39. KRYUGER, T. P. 1959. Dynamics of available forms of nitrogen and phosphorus in soils under rice cultivation. Doklady AN Uzbek SSR. (1):47-50. Abstract in Uzbek language. Bibliog. 6 refs.

40. Kuznetsov, K. A. 1959. Agricultural productive properties of soils and increasing their fertility. (Vostochnaya chast' Penzovskoy Oblasti). Penza. Published 1959, 71 pp. Bibliog. 22 refs.

41. KUZNETSOVA, A. V. 1959. Means of accumulating and conserving mineral forms of nitrogen in chernozems of the Southern Urals. Trudy Chelyabinskogo instituta mekhanizatsii i elektrifikatsii Sel'skogo Khozyaystva. Kafedra Zemledeliya. No. 10. Chelyabinsk. 204 pp. with illustr. Bibliog. 366 pp.

42. MANAKOV, A. F. 1957. Dynamics of soil fertility conditions in grassland garden beet crop rotation fields. Trudy Dzhambul'skoy sel'skokhoz. opytnoy stantsii. (Kazakhskaya akademiya sel'skokhoz. nauk). 1:47-59. Bibliog. 6 refs.

43. MARKEVICH, S. I. 1959. Phosphoric acid regime in sod-podzolic soils. Author's summary of a dissertation for candidate's degree in agricultural sciences. AN BSSR. Belorusskiy nauchnyy issledovatel'skiy institut zemledeliya. Minsk. 23 pp.

4. NESTYUK, N. N. 1958. Phosphorus and potassium fertility amounts and their residual effects on peat-bog soils. Trudy Instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva). 9:231-240.

5. NOVIKOVA, K. N. 1958. Physicochemical properties of gray forested steppe soils of Ul'yanovskaya Oblast' in connection with their possible liming. Trudy Ul'yanovskogo sel'skokhoz. instituta. 5(2): 65-69. Bibliog. 5 refs.

146. PCHELKIN, V. U., and S. M. KOZLOVA. 1959. Application of macrocrystalline and granulated potassium chloride. Udobreniye i Urozhay. (4):40-43.

147. RUDINA, L. A. 1959. Nutritive regime and structure of sod-meadow soils of the Moscow River flood plain. Author's summary of a dissertation for candidate's degree in biological sciences. (Moskovskyy gosudarstvennyy universitet. Biologicheskiy Pochvennyy fakul'tet.) Moscow. 20 pp.

148. SKOROPANOV, S. G. 1958. Cultivation of virgin bog and water-logged soils. (Doklady na Soveshchanii po obrabotke pochvy, sozv. VASKhNIL. Mart 1958). Trudy Instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii vodnogo khozyaystva). 9:155-166. Bibliog. 9 refs.

149. SYUNDYUKOV, KH. KH. 1959. A scientific agricultural basis for increasing fertility of virgin and abandoned land. Vestnik AN Kazakhsk. SSR. No. (2):15-20. Abstract in Kazakh language. Bibliog. 6 refs.

150. TADZHIYEVA, M. 1959. Fertilizer regime and cotton plant productivity. Udobreniye i Urozhay. (4):21-25.

151. KHLYSTOVSKIY, A. D. 1959. Effectiveness of fertilizer application to vegetables on soils of varying fertility. Udobreniye i Urozhay. (4):58-60.

152. SHAPOVALOV, V. 1959. Accumulation of nitrate and ammonium nitrogen in soil during reclamation of perennial abandoned lands. Sel'skoye Khozyaystvo Sibiri. (2):32-35.

153. SHEBEKO, V. F. 1958. Water requirement and moisture supply of agricultural crops on peat soils. (Doklady na 10-y nauchnoy konferentsii. Mart 1957 g.) Trudy Instituta (Belorusskiy nauchnyy issledovatel'skiy institut melioratsii i vodnogo khozyaystva). 9:55-70.

154. SHOPKHOYEV, S. P. 1958. Nitrate regime under basic field crops in leached chernozem of the Stavropol'skoye plateau. Trudy Stavropol'skogo sel'skokhozyaystvennogo instituta. (8):39-52. Bibliog. pp. 51-52.

155. SHCHERBATOV, F. M. 1958. Several results of studying the soil cultivation system using T. S. Maltsev's method in the Ul'yanovskaya Oblast' during the period

1955-1956. Trudy Ul'yanovskogo Sel'skokhoz. instituta. 5(2):39-49. With tables.

156. Agricultural nitrogen. Fertil. and Feed. Stuffs J. 1959. 60, 1:26-29.

157. ARENS, R. and J. STUCKMANN. 1959. Zur Frage der Wirkung organischer Dünger auf Gründland. Z. Acker-and, Pflanzenbau. 107, Ht. 4, S. 357-71. Bibl. 12.

158. BRENNER, J. M. 1958. Distribution of forms of nitrogen in soil profiles. Rothamst. exp. Sta., 1957. 57. p. Soils and Fertilizers, 6:2023.

159. BROMFIELD, S. M. 1958. The solution of x-MnO_2 by substances released from soil and from the roots of oats and vetch in relation to manganese availability. Plant and Soil, 10 No. 2:147-60.

160. COPE, J. T. 1958. a. oth. Effects of manure, vetch and commercial nitrogen on crop yields and carbon and nitrogen contents of a fine sandy loam over a 30-year period. Soil Sci. Soc. America Proc. 22 No. 6:524-27.

161. CROOKE, W. M. 1958. Effect of heavy-metal toxicity on the cation-exchange capacity of plant roots. Soil Sci. 86 No. 5:231-240.

162. EBERHARDT, W. 1958. Der Einfuss von Bodenbearbeitung und Kalkung auf den Gehalt an aktivem Mangan im Boden. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 82(127) Ht 2/3. 143-46.

163. GREACEN, E. L. 1958. Tillage and the control of soil fertility. Soils and Fertilizers, 21 No. 6:339-43. Bibl.

164. FEHRENBACHER, J. B. 1958. a. oth. Deep tillage and deep fertilization experiments on a claypan soil. Soil Sci. Soc. America Proc. 22 No. 6:553-57.

165. HAGIN, J. 1958. Availability of decalcium phosphate to plants, when applied in various forms. Plant and Soil 10 No. 2:101-113.

166. HENKENS, C. H. 1959. Control of manganese deficiency by fertilising the soil. Landbouwkund. tijdschr., 71 pp. 17-21.

167. HANNON, N. J. 1958. The status of nitrogen in the Hawkesbury sandstone soils and their plant communities in the Sydney district 2. The distribution and circulation of nitrogen. Proc. Linnean Soc. N. S. W., 83 pp. 65-84.

168. HOFMANN, E. u. L. WOLF. 1958. Über den Einfluss von Steinkohlen flugasche auf Boden und Pflanzenwachstum. Z. Pflanzenernähr., Düng., Bodenkunde. Bd. 82(127), Ht 2/3, 146-51.

169. JENNINGS, K. R., J. W. LINNETT, J. W. Active nitrogen. Quart. Revs. London, Chem. Soc., 1958, 12, No. 2:116-32. Bibliog. 43 tit.

170. KRZYSCH, G. 1958. Die Wirkungen verschiedener N, P- und K-Verbindungen bei Anwendung als Blattdungemittel. Z. Pflanzenernähr., Düng, Bodenkunde, Bd 82 (127), Ht. 2/3:107-120

171. KRZYSCH, G. 1958. Der N, -P- und K-Gehalt der Niederschläge in Dahlem. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 82(127), Ht. 2/3, S. 138-43.

172. LARSEN, J. E. 1958. a. oth. Studies of the leaching of applied labeled phosphorus in organic soils. Soil Sci. Soc. America Proc. 22 No. 6:558-60.

173. McKENZIE, W. M. 1958. The effect on nitrogen availability of adding fragmented wood to the soil. Austr. J. Agric. Res., v 9 N 5, 664-679.

174. MAPLES, R., R. L. BEACHER. 1958. Fertilization and soil test studies on cotton, 1953-55. Ark. Agric. Exp. Sta. Rep. Ser. 78, 32 pp.

175. MARZI, G. 1958. La concimazione fosfatic nel l'agricoltura italiana. Prog. agric., 4, No. 11:1300-1313.

176. MUNSON, R. D. and J. T. PESER. 1958. The effects of corn residue, nitrogen, and incumbation on nitrogen release and subsequent uptake by oats. A quanitative evaluation. Soil Sci. Soc. America Proc. v. 22, N 6, 543-47.

177. NORLAND, M. A. a. oth. Crop response to phosphate fertilizers as influenced by level of phosphorus solubility and by time of placement prior to planting. Ibid., p. 529-33.

178. PEARSON, G. A. and L. BERNSTEIN. 1958 Influence of exchangeable sodium on yield and chemical composition of plants 2. Wheat, barley, coats, rice, tall fescue, and tall wheatgrass. Soil Sci. 86 No. 5: 254-61.

179. PERKINS, H. F. and M. STELLY. Ca and Mg content of oats and crimson clover grown on Norfolk sandy loam as affected by Na and K. Ibid., No. 6:305-309.

180. Radio-isotopes in agriculture. Agric.

situation. India, 1958, 13 No. 9:781-83.

81. SCHACHTSCHABEL, P. u. K. HARTGE. 1 1958. Die Verbesserung der Strukturstabilität von Ackerböden durch eine Kalkung. Z. Pflanzenernähr., Düng., Bodenkunde, Bd. 83(128), Ht. 3, S. 193-202.

82. SCHARRER, K. u. K. MENGEL. Über den Kalium-Magnesium-Antagonismus bei Mais und Sonnenblumen. Ibid., Ht 2, S. 149-62. Bibl.

83. SCHILLER, H., V. JANIK. 1958. Der Nährstoffgehalt der Boden in seiner Beziehung zum Einzugsgebiet der Flüsse. Bodenkultur, 10A, S. 1-15.

84. SEGEBERG, H. Gewächshausversuche zur Bestimmung des Welkepunktes humoser Sandboden. Z. Pflanzenernähr. Dung., Bodenkunde, Bd. 82 (127), Ht. 2/3, s. 131-164.

85. SIMON-SYLVESTRE, G. 1958. En fouissement de paille et developpement de bacteries cellulolytiques aerobies dans le sol. C. r. Acad. Sci., 246, No. 12:1238-1240.

86. SMITH, F. W. and J. GRAVA. Availability of phosphorus contained in phosphate shale compared to that contained in monocalcium phosphate and raw rock phosphate. Soil Sci., v. 86, No. 5:313-18.

87. VALDMAN, K. The action of phosphate fertilization on the properties of a peat soil humus. Acta agric. scand., 8 No. 3:

88. WARING, S. A. 1958. a. oth. Fertility investigations on the black earth wheatlands of the Darling Downs, Queensland. 2. Moisture and evaporanspiration in relation to the wheat crop. Austral. J. Agric. Res., 9, No. 6:717-729.

89. WEBB, J. R. and J. T. PSESK. 1958. An evaluation of phosphorus fertilizer varying in water solubility. I. Hill application for corn. Soil Sci. Soc. America Proc. 22, No. 6:533-38.

90. WILLIAMS, R. F. 1958. a. oth. Studies in soil fertility with special reference to organic manures. 4. Effects of glucose on phosphate availability. Austral. J. Agric. Res., 9, No. 5:640-63.

SOIL MELIORATION

1. BOERU, S. si R. MINDRU. 1958. Ameliorarea terenurilor inundabile si mlastinoase. Bucuresti, 542 c. Bibl. 131 n.

192. AGAKHANYAN, G. A. 1958. Specific characteristics of natural conditions and reclamation requirements in the central and western districts of Armenia. Trudy Armyanskogo nauchnogo issledovatel'skogo instituta gidrotekhniki i melioratsii. 3:167-181.

193. BEKMAMBETOV, R. 1959. Reclamation of solonetzes in northern Kazakhstan. Sel'skoye Khozyaystvo Kazakhstana (2): 23-28.

194. BEKHBUDOV, A. 1959. Several problems in determining models of the drainage flow and interdrainage distances on salinized soils. Sel'skoye Khozyaystvo Azerbaydzhana, (2):50-54.

195. DASHIYEV, T. I. 1958. Specific characteristics of bog reclamation under northern conditions of drainage. Trudy Instituta (Severnyy nauchnyy issledovatel'skiy institut gidrotekhniki i melioratsii). 15): 94-141. Bibliog. 19 refs.

196. ZNAMENSKAYA, YE. I. 1959. Irrigation on leached chernozems. Sel'skoye khozyaystvo Sev. Kavkaza. (4):78-80.

197. KIM, F. 1959. Flood regime of flood-plain estuaries in the semidesert zone of western Kazakhstan. Sel'skoye khozyaystvo Kazakhstana. (2):65-67.

198. KLIMKO, A. I. 1958. Regulating the water regime of soil by a thin network of ditches combined with agricultural reclamation measures. Trudy Instituta (Severnyy nauchnyy issledovatel'skiy institut gidrotekhniki i melioratsii). (15):7-23.

199. KRIGER, R. E. 1959. Flooding standards of deep and shallow water estuaries. Gidrotekhnika i melioratsiya. (3):7-18. Bibliog. 13 refs.

200. MUSTAFAYEV, M. 1959. Closed drainage with filtering devices. Sots. S. Kh. Azerbaydzhana. No. (2):57.

201. PAVLOV, B. 1959. Terracing mountain slopes for perennial plantings. Vinogradarstvo i sadovodstvo Kryma. (2):26-27.

202. RAFAELYAN, A. S. 1959. Application of mole drainage to soils of the Priaraksinskaya Valley, Armyanskaya SSR. Author's summary of a dissertation for candidate's degree in Agricultural Sciences. (Institut Pochvovedeniya i Agrokhimii M-va S. Kh. Armyanskaya SSR) Yerevan, 21 pp. with graphs.

203. SUSLOV, A. 1959. Prospects of irrigation

development in Uzbek SSR. Narodnoye khozyaystvo Uzbekistana. (2):67-74.

204. KHUDAYBERDYYEV, A. A. 1959. Regulating the water-salt regime of the Bukharskiy Oasis soils based on using subterranean waters for irrigation. Sel'skoye Khozyaystvo Uzbekistana. (1):70-76.

205. FLODKVIST, H. und Y. GUSTAFSSON. 1958. Grundwasserabfluss aus Dransystemen als Funktion meteorologischer Faktoren. Acta Agric. scand., 8 No. 3:23, 1-65. Bibl.

206. NICOLLS, K. D. 1958. Tasmanian climate topography and soils in relation to irrigation potential. J. Austr. Inst. Agric. Sci., 24 No. 3:200-204.

207. SHAH, R. K. 1958. a. oth. Possibilities of reclamation of the alkali soils of the Little Rann of Cutch. J. Soil and Water Conservat. India, 6 No. 3:133-37.

SOIL EROSION AND ITS CONTROL

208. BARAYEV, A. I. 1958. Measures for controlling wind erosion of soil. Vestnik sel'skokhoz. nauki (Alma-Ata) (3):47-55. Abstract in the Kazakh language.

209. BUDAK, P. 1959. Our measures for preventing (Kolkhoz "Znamya Pobedy." Kotovskiy rayon). Zemledeliye i zhivotnovodstvo Moldavii. (2):26.

210. VORONTSOV, V. V. 1959. Controlling soil erosion. Sots. Sel'skoye khozyaystvo Azerbaydzhana. (2):11-13.

211. D'YACHENKO, A. YE. 1958. Study of soil deflation (wind erosion). Vestnik sel'skokhoz. nauki. (Alma-Ata)(3):33-46. In the Kazakh language. Bibliog. 11 refs.

212. ZAYTSEV, V. T. 1959. Forest belts for controlling soil erosion. Sadovodstvo, Vinogradarstvo i vinodeliye Moldavii. (1):8-11.

213. ZAYTSEV, V. 1959. Role of forest plantations in controlling erosion. Zemledeliye i zhivotnovodstvo Moldavii. (2):21-22.

214. ZASLAVSKIY, M. 1959. Organizing erosion control in the Chinese People's Republic. Zemledeliye i zhivotnovodstvo Moldavii. (2):27-29.

215. KISELEV, A. N. 1958. Wind erosion and methods of control. Vastnik sel'skokhoz. nauki (Alma-Ata) (3):56-64. Abstract in Kazakh language.

216. KOSTROVSKIY, S. 1959. Dust storms in the Altay steppes. Sel'skoye khozyaystvo Sibiri. (2):35-37.

217. MAKARYCHEV, N. T. 1958. Several forest improvement problems in deflated (wind erosion) districts of northern Kazakhstan. Vestnik sel'skokhozyaystvennoy nauki (Alma-Ata) (3):84-88. Abstract in the Kazakh language.

218. MATUSEVICH, S. P. 1958. Wind eroded soils of the northern regions of Kazakhstan. Vestnik sel'skokhoz. nauki (Alma-Ata) (3):5-10. Abstract in Kazakh language.

219. PAVLENKO, G. V. 1958. Principal factors of spring runoff of rivers in the Kulundinskaya steppe. Izv. Novosib. otd. Geogr. obshchestva SSSR. (2):51-65. Bibliog. 23 refs. 23 references.

220. PETROV, M. P. 1959. Forest and land reclamation of desert sands in the Chines People's Republic. Sel'skoye khozyaystvo Turkmenistana. (1):59-65.

221. PODVISHENSKAYA, N. YA. 1959. The character of flow distribution for rivers at the time when rain-fed. Trudy Tsentral'nogo instituta prognozov. (82): 59-63.

222. SDOBNIKOV, S. S. and I. YA. POLOVITSKI 1958. A program and methods of studyin wind erosion of soils. Vestnik sel'skokho nauki (Alma-Ata) (3):25-32. Abstract in Kazakh language.

223. SUBBOTIN, A. I., 1959. Specific characteristics of the formation of spring runoff in basins with podzolic-clay loam soils. Trudy Tsentral'nogo Instituta prognozov. No. 82. pp. 3-58. Bibliog. 40 references.

224. TUROVTSEV, M. M. 1958. Controlling dust storms in the Bashkirskaya ASSR. Vestnik sel'skokhoz nauki (Alma-Ata) No. 3. pp. 65-72. With maps. Abstract in the Kazakh language.

225. BERTONI, J. 1958. a. oth. Determination of infiltration rates on Marchall silt loam from runoff and rainfall records. Soil Sci. Soc. America Proc., 22 No. 6: 571-574.

226. CHRISTIE, E. A. 1958. Controlling a spring fed gully. Soil Conservat., 22 No. 3:51-52.

227. MIRCHANDANI, P. M. 1958. a. oth Runoff soil loss studies an Deochanda experiment station. I. Effect of crop manage-

ment practices. J. Soil and Water Conservation. India 6 No. 3:125-32 Bibl.

8. RICHARDSON, E. C. 1958. a. oth. Highway erosion control in Northwest Georgia. Soil Conservat., 24, No. 3:58-60.

9. SITARAMAN, S. 1958. Certain aspects of water conservation and soil erosion in Nepal. J. Soil and Water Conservat. India. 6, No. 3:121-25.

230. Moisture and soil retention in the loess plateau of the middle course of the Khuankhe River. Peking, 1958. 114 pp.

231. TURNER, A. K. 1958. The construction of earth dams for farm water suppl. J. Austral. Inst. Agric. Sci. 24 No. 3: 220-25.

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